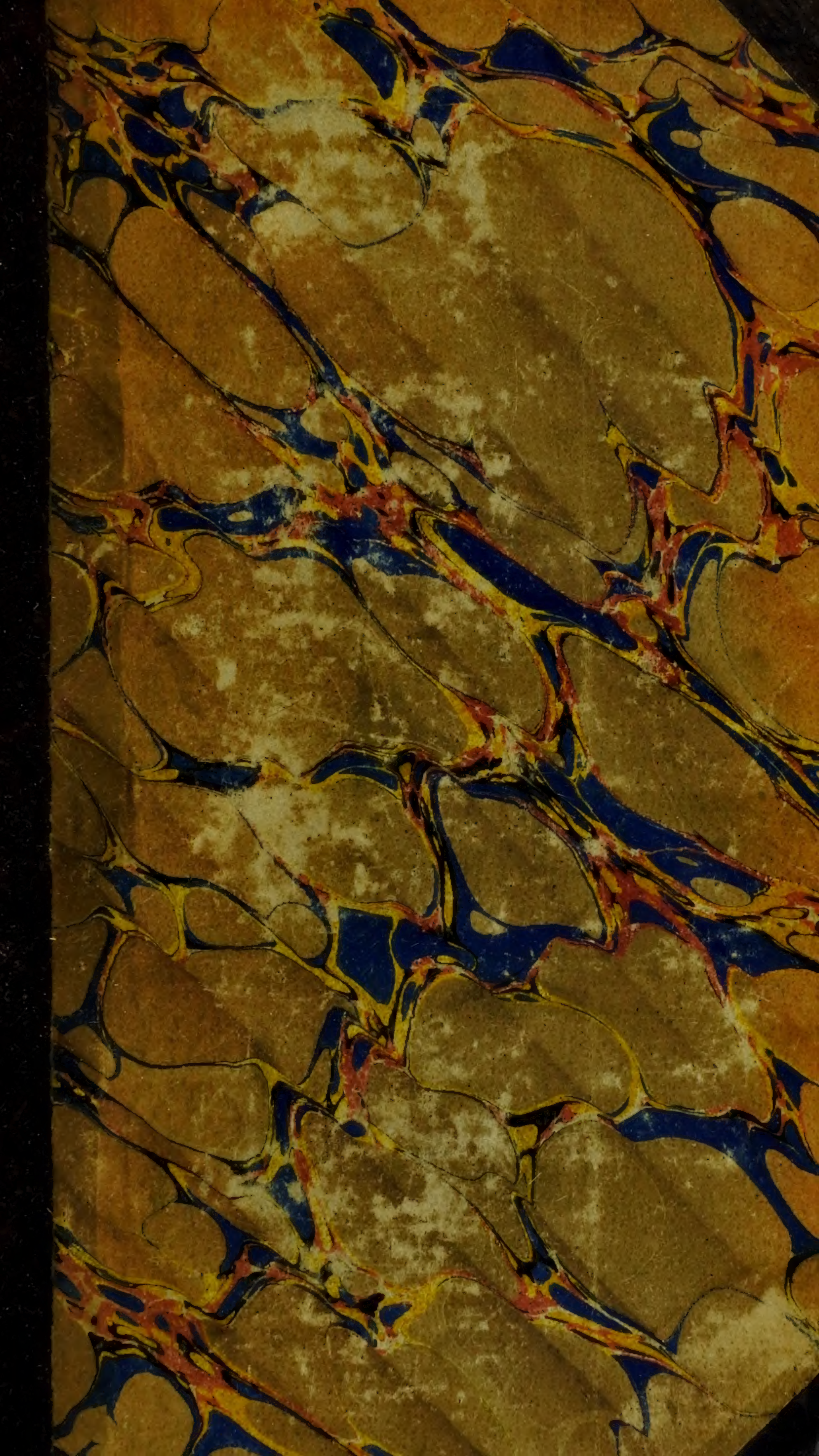


LAVOISIER, A.L.
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ELEMENTS

OF

CHEMISTRY,

IN A

NEW SYSTEMATIC ORDER,

CONTAINING ALL THE

MODERN DISCOVERIES.

ILLUSTRATED BY THIRTEEN COPPERPLATES.

BY

MR LAVOISIER,

Member of the Academies and Societies of Paris, London, Orleans, Bologna, Basil, Philadelphia, Haerlem, Manchester, &c. &c.

TRANSLATED FROM THE FRENCH

BY ROBERT KERR, F. R. & A. SS. EDIN.

Member of the Royal College of Surgeons, and of the Royal Physical Society of Edinburgh.

FIFTH EDITION,

WITH

NOTES, TABLES, AND CONSIDERABLE ADDITIONS.

IN TWO VOLUMES.

VOL. I.

EDINBURGH:

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1802.

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Old Fishmarket, Edinburgh.

TO

CHARLES KERR, Esq.

OF CALDER-BANK.

No opportunity more favourable can occur of recording my warm ſentiments of affection and eſteem, than by uniting them with the immortality of Lavoisier.

I remain, moſt ſincerely,

Your Friend and Brother,

Robert Kerr.

Millbank, Ayton,
June 10. 1802.

ADVERTISEMENT

OF THE

TRANSLATOR

TO THIS FIFTH EDITION.

THE very high character which the late celebrated Mr Lavoiſier has ſo deſervedly acquired as a chemical philoſopher, and the great revolution which he, principally, has effected in the theory of chemiſtry, had long made it greatly deſired, by all cultivators of phyſical ſcience, to have a connected account of his diſcoveries, and thoſe of other chemical philoſophers, on which his opinions are founded, together with an accurate expoſition of the new theory, or rather of the regular concatenation of facts, which he has eſtabliſhed, in conſequence of theſe diſcoveries made by himſelf and others. For the performance of this arduous undertaking, no one could be better qualified than Mr Lavoiſier him-

 ſelf:

ſelf: He was not only thoroughly converſant in the diſcoveries of other philoſophers, having, with infinite pains, repeated all their important experiments, and ſo varied moſt of them, as to bring their reſults into a much clearer view, but was himſelf the author of many important diſcoveries. The hiſtory, therefore, of theſe diſcoveries, and their proper arrangement, for conveying an exact idea of the new theory which he had deduced from them, could not, certainly, have been given to the world ſo well, or with ſo much propriety, by any other perſon.

This great deſideratum, in the hiſtory and ſcience of chemiſtry, was accompliſhed in the year 1789, by the publication at Paris of theſe *Elements of Chemiſtry* by Mr Lavoiſier; and a copy of that excellent work having ſoon after fallen accidentally into the hands of the Tranſlator, he was eager to give it to the public in Engliſh. He has received infinite ſatisfaction from the favourable reception experienced by his firſt attempt to merit the favour of the public; and whatever heſitation he may have originally felt, on a firſt appearance, even in the

the character of a Tranſlator, ſo many editions having been rapidly exhauſted, is ſufficient inducement to repeat the impreſſions as called for.

A new edition of the original having been announced at Paris, in the winter 1792-3, expectations were formed that the illuſtrious Author might have made conſiderable improvements; but, from a correſpondence with Mr Lavoiſier, the Tranſlator is enabled to ſay, that the new edition, having been printed without his knowledge, is entirely a tranſcript from the former.

The Tranſlator has been much importuned by his friends, to publiſh the letter he had the honour of receiving from the illuſtrious Author of this book. After withholding it in the three laſt editions, he now ventures to annex it to this advertiſement; but thinks it moſt decorous that it ſhould remain in the French.

In the original of theſe Elements, the thermometrical ſcale of Reaumeur is employed, for deſcribing the degrees of temperature in the various experiments: In all the editions of this tranſlation after the firſt, theſe degrees have been uniformly

 transferred

transferred into their correſponding degrees on the ſcale of Fahrenheit, which is univerſally uſed by Britiſh philoſophers. The *centigrade* ſcale, originally employed in Sweden, is certainly preferable to all others, and is now common in France. In the appendix to the ſecond volume, No. IV. rules are given for reducing the ſcales of the moſt generally uſed thermometers into each other.

The weights employed by Mr Lavoiſier, for detailing the ingredients and reſults of his various experiments, are, in the original, expreſſed in the cuſtomary aliquot parts of the old Paris pound, *poids de marc*, which is divided very differently from the Engliſh pound, either troy or avoirdupois. To render the weights detailed in theſe experiments fully intelligible to the Britiſh reader, they are all, ſince the ſecond edition, reduced to decimal fractions of the pound, which will ſerve for all denominations, and ought to be univerſally uſed in ſcientific labours.

In the courſe of the tranſlation, ſeveral explanatory notes are added, principally for the purpoſe of rendering the doctrines of the Author more readily underſtood by beginners,

ginners, and by thoſe who have only been accuſtomed to the old language of chemiſtry. In conſequence, however, of the perſpicuity of the Author, much fewer of theſe were found neceſſary than might have been expected, conſidering the comprehenſive nature of the work. It was intended by the Author to convey a general view of the new chemical theory, rather than to give a ſyſtem of chemiſtry: yet, ſuch is the excellence of its plan and execution, that, with theſe limited intentions, it is the beſt body of chemical philoſophy extant.

In a ſmall number of places, the Tranſlator has taken the liberty of throwing to the bottom of the page, in notes, ſome parenthetical expreſſions, not directly connected with the ſubject; which, in their original place, ſeemed rather to confuſe the ſenſe of the paſſages in which they ſtood. Theſe, and the original notes of the Author, are diſtinguiſhed by the letter A; and to thoſe which the Tranſlator has ventured to give, the letter T is ſubjoined.

Some very material additions have been made by the Tranſlator, in the various editions, relative to ſuch diſcoveries as have taken

taken place in different parts of chemiſtry ſince the publication of the original; but as theſe are all diſtinctly marked in their proper places in the courſe of the work, it is not neceſſary to particularize them here.

The additions which have been made to this fifth edition, have been ſo numerous, as to make it neceſſary to divide the work, as in the original, into two volumes. A copious index is now firſt added.

Had not the illuſtrious Author been cut off, in the full vigour, and ſplendid yet ſolid career, of his philoſophical purſuits, by the monſter who tyrannized over France, and convulſed the world by his enormous crimes, his intended republication of this work, on a new plan, as mentioned in his letter to the Tranſlator, would aſſuredly have given the world a very perfect ſyſtem of chemiſtry in all its parts. In the rapidly advancing ſtate of chemiſtry, not, alas! to compenſate the irreparable loſs of the juſtly famous Author, the Tranſlator has dared to attach ſome notices of thoſe progreſſive improvements to the text of theſe Elements; together with ſome additions at the end, of which he was not poſſeſſed of

information

information while the preſent edition was in progreſs. All of theſe are carefully diſtinguiſhed, leſt any eſcapes from his own imperfect knowledge ſhould derogate from the high and merited fame of his immortal Author. May theſe endeavours, to aid the progreſs of chemical ſcience, be acceptable to the indulgent public, as his humble, yet willing tribute, to the immortal memory of the great Lavoiſier!

In the original, Mr Lavoiſier gave, in an appendix, ſeveral very uſeful tables, for facilitating the calculations now neceſſary in the advanced ſtate of chemiſtry, wherein the moſt ſcrupulous accuracy is required. Theſe are now as indiſpenſably requiſite to the operations of the chemical philoſopher, as the Ephemerides, and Nautical Almanacs, and Logarithmic Tables, are to the Navigator, Aſtronomer, and Geometrician. Theſe tables are all retained in this tranſlation, being, however, reduced to the ſtandards of Britiſh weights and meaſures, with appropriate rules for making the neceſſary converſions from the weights and meaſures of old France, as uſed by the Author: And the Tranſlator is proud to acknowledge his obligations

obligations to the learned Profeſſor of Natural Philoſophy in the Univerſity of Edinburgh, and to his friend Dr Rotheram, formerly Aſſiſtant to the late illuſtrious Dr Black, Profeſſor of Chemiſtry in the Univerſity of Edinburgh, and now Profeſſor of Natural Philoſophy in the Univerſity of St Andrew's; both of whom kindly ſupplied him with the neceſſary information, and took the trouble of making a number of very laborious calculations for this purpoſe. With the ſame obliging aſſiſtance, ſeveral very uſeful additional tables have been given in the appendix, which need not be here enumerated, as they will diſtinctly appear in their proper places.

POSTSCRIPT

TO THE

THIRD EDITION.

THE Philoſophical World has now infinitely to deplore the tragical and untimely death of the great LAVOISIER; who has left a rare example of ſplendid talents and great

great wealth, at the ſame time immerſed in numerous and important public employments, which he executed with diligent intelligence, and devoting his princely fortune, and vaſt abilities, to the ſedulous cultivation, and moſt ſucceſsful improvement, of the ſciences. If the ſanguinary tyranny of the monſter Robeſpierre had committed only that outrage againſt eternal Juſtice, a ſucceeding age of the moſt perfect government, would ſcarcely have ſufficed to France and to the world, to repair the prodigious injury that loſs has produced to chemiſtry, and to all the ſciences and economical arts with which it is connected.

Had Lavoiſier lived, as expreſſed in a letter * received from him by the Tranſlator a ſhort while before his maſſacre, it was his intention to have republiſhed theſe elements in an entirely new form, compoſing a Complete Syſtem of Philoſophical Chemiſtry : And, as a mark of his ſatisfaction with the fidelity of this tranſlation, he propoſed to have conveyed to the Tranſlator, ſheet by ſheet as it ſhould come from the preſs, that new and invaluable work, alas ! now for ever loſt.

LET-

* Now ſubjoined.

LETTER

FROM THE

AUTHOR TO THE TRANSLATOR.

Paris, 6 *Janvier* 1793.
MONSIEUR, *L'an* 2 *de la République*.

IL eſt vrai que l'imprimeur, qui s'étoit chargé de la publication de mes Elemens de Chimie, vient d'en donner une ſeconde édition; mais c'eſt à mon inſçu, et ſans que j'y aye fait le plus léger changement. C'eſt donc plutôt une contrefaction, qu'une ſeconde édition.

Je ne puis au-ſurplus voir qu'avec bien de la reconnoiſſance l'intention où vous m'annoncés être d'entreprendre la traduction en Anglois d'une ſeconde édition. Je vous prie de me reſerver cette bonne volonté pour un autre tems; car depuis que j'ai abſolument

ſolument renoncé à toutes les affaires publiques, et que j'ai réſolu de donner aux ſciences tout mon tems, j'ai entrepris des Elemens de Chimie ſur un plan beaucoup plus vaſte. Je ne penſe pas que la publication puiſſe en être faite avant deux ans, et je m'empreſſerai de vous en adreſſer un exemplaire, feuille par feuille, ſi vous le deſirés, dès que l'impreſſion ſera commencée; mais ce n'eſt que dans un an au plutôt que je pourrai commencer les envoys. Je vous prierai alors de m'indiquer la voye par laquelle vous jugerés à-propos que je faſſe les envoys.

J'ai reçu dans le tems l'exemplaire que vous avés bien voulu m'envoyer de votre excellente traduction. Je m'y trouve preſque toujours plus clair que dans le texte.

Si je ne vous ai point écrit, c'eſt que j'étois livré à des occupations d'un genre bien different: on pouvoit alors eſpérer de ſe rendre utile dans les places de l'adminiſtration; mais aujourd'hui que la France eſt en proye aux factions, il devient extrêmement difficile de faire le bien, et il faut être ou bien ambitieux ou bien inſenſé, pour aſpirer aux grandes places.

J'ai

J'ai l'honneur d'être, avec la plus parfaite consideration,

MONSIEUR,

votre très humble, et très

obéissant Serviteur,

LAVOISIER.

To Mr Kerr, care of Mr Creech, Edinburgh, Britain.

PREFACE

PREFACE

OF THE

AUTHOR.

WHEN I began the following Work, my only object was to extend and explain more fully the Memoir which I read at the public meeting of the Academy of Sciences in the month of April 1787, on the neceſſity of reforming and completing the Nomenclature of Chemiſtry. While engaged in this employment, I perceived, better than I had ever done before, the juſtice of the following maxims of the Abbé de Condillac, in his Syſtem of Logic, and ſome other of his works.

"We think only through the medium of
" words.—Languages are true analytical me-
" thods.—Algebra, which is adapted to its pur-
" poſe in every ſpecies of expreſſion, in the moſt
" ſimple, moſt exact, and beſt manner poſſible,
" is at the ſame time a language and an analy-
" tical method.—The art of reaſoning is nothing
" more than a language well arranged."

Thus, while I thought myſelf employed only in forming a Nomenclature, and while I propoſed to myſelf nothing more than to improve the chemical language, my work transformed itſelf by degrees, without my being able to prevent it, into a treatiſe upon the Elements of Chemiſtry.

The impoſſibility of ſeparating the Nomenclature of a ſcience from the ſcience itſelf, is owing to this, that every branch of phyſical ſcience muſt conſiſt of three things; the ſeries of facts which are the objects of the ſcience; the ideas which repreſented theſe facts; and the words by which theſe ideas are expreſſed. Like three impreſſions of the ſame ſeal, the word ought to produce the idea, and the idea to be a picture of the fact. And, as ideas are preſerved and communicated by means of words, it neceſſarily follows, that we cannot improve the language of any ſcience, without at the ſame time improving the ſcience itſelf; neither can we, on the other hand, improve a ſcience, without improving the language or nomenclature which belongs to it. However certain the facts of any ſcience may be, and however juſt the ideas we may have formed of theſe facts, we can only communicate

falſe

falſe or imperfect impreſſions of theſe ideas to others, while we want words by which they may be properly expreſſed.

To thoſe who will conſider it with attention, the firſt part of this treatiſe will afford frequent proofs of the truth of theſe obſervations. But as, in the conduct of my work, I have been obliged to obſerve an order of arrangement eſſentially differing from what has been adopted in any other chemical work yet publiſhed, it is proper that I ſhould explain the motives which have led me to adopt that arrangement.

It is a maxim univerſally admitted in Geometry, and indeed in every branch of knowledge, that, in the progreſs of inveſtigation, we ſhould proceed from known facts to what is unknown. In early infancy, our ideas ſpring from our wants, the ſenſation of want exciting the idea of the object by which it is to be gratified. In this manner, from a ſeries of ſenſations, obſervations, and analyſes, a ſucceſſive train of ideas ariſes, ſo linked together, that an attentive obſerver may trace back, to a certain point, the order and connection of the whole ſum of human knowledge.

When we begin the ſtudy of any ſcience, we are in a ſituation, reſpecting that ſcience, ſimilar to children; and the courſe by which we have to advance, is preciſely the ſame which Nature follows in the formation of their ideas. In a child, the idea is merely an effect produced by a ſenſation; and, in the ſame manner, in commencing the ſtudy of a phyſical ſcience, we ought to form no idea but what is a neceſſary conſequence, and immediate effect, of an experiment or obſervation. Beſides, he who enters upon the career of ſcience, is in a leſs advantageous ſituation than a child who is acquiring his firſt ideas. To the child, Nature gives various means for rectifying any miſtakes he may commit, reſpecting the ſalutary or hurtful qualities of the objects which ſurround him. On every occaſion his judgments are corrected by experience; want and pain are the neceſſary conſequences ariſing from falſe judgment; gratification and pleaſure are produced by judging aright. Under ſuch maſters, we cannot fail to become well informed; and we ſoon learn to reaſon juſtly, when want and pain are the neceſſary conſequences of a contrary conduct.

In the ſtudy and practice of the ſciences it is entirely

entirely different; the falſe judgments we may form neither affect our exiſtence nor our welfare; and we are not compelled by any phyſical neceſſity to correct them. Imagination, on the contrary, which is ever wandering beyond the bounds of truth, joined to ſelf-love, and that ſelf-confidence we are ſo apt to indulge, prompt us to draw concluſions which are not immediately derived from facts; ſo that we become in ſome meaſure intereſted in deceiving ourſelves. Hence it is by no means ſurpriſing, that, in the ſcience of phyſics in general, men have ſo often formed ſuppoſitions, inſtead of drawing concluſions. Theſe ſuppoſitions, handed down from one age to another, acquire additional weight from the authorities by which they are ſupported, till at laſt they are received, even by men of genius, as fundamental truths.

The only method of preventing ſuch errors from taking place, and of correcting them when formed, is to reſtrain and ſimplify our reaſoning as much as poſſible. This depends entirely on ourſelves, and the neglect of it is the only ſource of our miſtakes. We muſt truſt to nothing but facts: Theſe are preſented to us by Nature, and cannot deceive. We ought, in every inſtance,

to submit our reasoning to the test of experiment, and never to search for truth, but by the natural road of experiment and observation. Thus mathematicians obtain the solution of a problem, by the mere arrangement of data, and by reducing their reasoning to such simple steps, and to conclusions so very obvious, as never to lose sight of the evidence which guides them.

Thoroughly convinced of these truths, I have imposed upon myself, as a law, never to advance but from what is known to what is unknown; never to form any conclusion which is not an immediate consequence necessarily flowing from observation and experiment; and always to arrange the facts, and the conclusions which are drawn from them, in such an order as shall render it most easy for beginners in the study of chemistry thoroughly to understand them. Hence I have been obliged to depart from the order usually observed in courses of lectures and treatises upon chemistry; which always assume the first principles of the science as known, whereas the pupil or the reader should never be supposed to know them till they have been explained in subsequent lessons. In almost every instance, chemical authors and lecturers begin by treating of

of the elements of matter, and by explaining the table of affinities; without confidering, that, in fo doing, they muft bring the principal phenomena of chemiftry into view at the very outfet: They make ufe of terms which have not been defined, and fuppofe the fcience to be underftood by the very perfons they are only beginning to teach.

It ought likewife to be confidered, that very little of chemiftry can be learned in a firft courfe, which is hardly fufficient to make the language of the fcience familiar to the ears, or the apparatus familiar to the eyes. It is almoft impoffible to become a chemift in lefs than three or four years of conftant application.

Thefe inconveniences are occafioned, not fo much by the nature of the fubject, as by the method of teaching it; and, to avoid them, I was chiefly induced to adopt a new arrangement of chemiftry, which appeared to me more confonant to the order of Nature. I acknowledge, however, that in thus endeavouring to avoid difficulties of one kind, I have found myfelf involved in others of a different fpecies, fome of which I have not been able to remove; but I am per-

ſuaded, that ſuch as remain do not ariſe from the nature of the order I have adopted, but are rather conſequences of the imperfection under which chemiſtry ſtill labours. This ſcience has many chaſms, which interrupt the ſeries of facts, and often render it extremely difficult to reconcile theſe with each other: It has not, like the elements of geometry, the advantage of being a complete ſcience, the parts of which are all cloſely connected together: Its actual progreſs, however, is ſo rapid, and the facts, under the modern doctrine, have aſſumed ſo happy an arrangement, that we have ground to hope, even in our own times, to ſee it approach near to the higheſt ſtate of perfection of which it is ſuſceptible.

The rigorous law from which I have never deviated, of forming no concluſions which are not fully warranted by experiment, and of never ſupplying the abſence of facts, has prevented me from comprehending in this work the branch of chemiſtry which treats of affinities, although it is perhaps the beſt calculated of any part of chemiſtry for being reduced into a completely ſyſtematic body. Meſſrs Geoffroy, Gellert, Bergman, Scheele, De Morveau, Kirwan, and many others,

others, have collected a great number of particular facts upon this subject, which only wait for a proper arrangement: but the principal data are still wanting; or, at least, those we have are either not sufficiently defined, or not sufficiently proved, to become the foundation for so very important a branch of chemistry. This science of affinities, or elective attractions, holds the same place with regard to the other branches of chemistry, that the higher or transcendental geometry does with respect to the simpler and elementary part; and I thought it improper to involve those simple and plain elements, which I flatter myself the greatest part of my readers will easily understand, in the obscurities and difficulties which still attend that other very useful and necessary branch of chemical science.

Perhaps a sentiment of self-love may, without my perceiving it, have given additional force to these reflections. Mr de Morveau * is at present engaged in publishing the article *Affinity* in the Methodical Encyclopædia; and I had more reasons than one to decline entering upon a work in which he is employed.

It will, no doubt, be a matter of surprise, that in

* Now Guyton.

in a treatiſe upon the elements of chemiſtry, there ſhould be no chapter on the conſtituent and elementary parts of matter; but I may here obſerve, that the fondneſs for reducing all the bodies in nature to three or four elements, proceeds from a prejudice which has deſcended to us from the Greek Philoſophers. The notion of four elements, which, by the variety of their proportions, compoſe all the known ſubſtances in nature, is a mere hypotheſis, aſſumed long before the firſt principles of experimental philoſophy or of chemiſtry had any exiſtence. In thoſe days, without poſſeſſing facts, they framed ſyſtems; while we, who have collected facts, ſeem determined to reject even theſe, when they do not agree with our prejudices. The authority of thoſe fathers of human philoſophy ſtill carry great weight, and there is reaſon to fear that it will even bear hard upon generations yet to come.

It is very remarkable, notwithſtanding the number of philoſophical chemiſts who have ſupported the doctrine of the four elements, that there is not one who has not been led, by the evidence of facts, to admit a greater number of elements into their theory. The firſt chemical authors, after the revival of letters, conſidered

ſulphur

ſulphur and ſalt as elementary ſubſtances entering into the compoſition of a great number of bodies; hence, inſtead of four, they admitted the exiſtence of ſix elements. Beccher aſſumed the exiſtence of three kinds of earth; from the combination of which, in different proportions, he ſuppoſed all the varieties of metallic ſubſtances to be produced. Stahl gave a new modification to this ſyſtem: And ſucceeding chemiſts have taken the liberty to make or to imagine changes and additions of a ſimilar nature. All theſe chemiſts were carried along by the genius of the age in which they lived, being ſatisfied with aſſertions inſtead of proofs; or, at leaſt, often admitting as proofs the ſlighteſt degrees of probability, unſupported by that ſtrictly rigorous analyſis which is required by modern philoſophy.

All that can be ſaid upon the number and nature of elements is, in my opinion, confined to diſcuſſions entirely of a metaphyſical nature. The ſubject only furniſhes us with indefinite problems, which may be ſolved in a thouſand different ways, not one of which, in all probability, is conſiſtent with nature. I ſhall, therefore, only add upon this ſubject, that if, by the term *elements*, we mean to expreſs thoſe ſimple and indiviſible

indivifible atoms of which matter is compofed, it is extremely probable we know nothing at all about them; but, if we apply the term *elements* or *principles of bodies*, to exprefs our idea of the laft point which analyfis is capable of reaching, we muft admit, as elements, all the fubftances into which we are able to reduce bodies by decompofition. Not that we are entitled to affirm, that thefe fubftances which we confider as fimple, may not themfelves be compounded of two, or even of a greater number of more fimple principles; but fince thefe principles cannot be feparated, or rather fince we have not hitherto difcovered the means of feparating them, they act with regard to us as fimple fubftances, and we ought never to fuppofe them compounded until experiment and obfervation have proved them to be fo.

The foregoing reflections upon the progrefs of chemical ideas naturally apply to the words by which thefe ideas are expreffed. Guided by the work which, in the year 1787, Meffrs de Morveau, Berthollet, de Fourcroy, and I compofed upon the Nomenclature of Chemiftry, I have endeavoured, as much as poffible, to denominate fimple bodies by fimple terms, and I was naturally

rally led to name theſe firſt. It will be recollected, that we were obliged to retain that name of any ſubſtance by which it had been long known in the world, and that in two caſes only we took the liberty of making alterations; firſt, in the caſe of thoſe which were but newly diſcovered, and had not yet obtained names, or at leaſt which had been known but for a ſhort time, and the names of which had not yet received the ſanction of the public; and ſecondly, when the names which had been adopted, whether by the ancients or the moderns, appeared to us to expreſs evidently falſe ideas; when they confounded the ſubſtances, to which they were applied, with others poſſeſſed of different, or perhaps oppoſite qualities. We made no ſcruple, in this caſe, of ſubſtituting other names in their room, and the greater number of theſe were borrowed from the Greek language. We endeavoured to frame them in ſuch a manner as to expreſs the moſt general and the moſt characteriſtic quality of the ſubſtances; and this was attended with the additional advantage both of aſſiſting the memory of beginners, who find it difficult to remember a new word which has no meaning, and

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of accuſtoming them early to admit no word without connecting with it ſome determinate idea.

To thoſe bodies which are formed by the union of ſeveral ſimple ſubſtances, we gave new names compounded in ſuch a manner as the nature of the ſubſtances directed; but, as the number of known double combinations is already very conſiderable, the only method by which we could avoid confuſion, was to divide theſe into claſſes. In the natural order of ideas, the name of the claſs or genus is that which expreſſes a quality common to a great number of individuals; the name of the ſpecies, on the contrary, expreſſes a quality peculiar to certain individuals only.

Theſe diſtinctions are not, as ſome may imagine, merely metaphyſical, but are eſtabliſhed by nature. "A child," ſays the Abbé de Condillac, "is taught to give the name *tree* to the "firſt which is pointed out to him. The next "tree he ſees preſents the ſame idea, and he "gives it the ſame name. This he does likewiſe "to a third and a fourth, till at laſt the word "*tree*, which he at firſt applied to an individual, "comes to be employed by him as the name of "a

" a claſs or a genus ; it becomes an abſtract idea, " which comprehends all trees in general. But " when he learns that all trees do not ſerve the " ſame purpoſe, that they do not all produce " the ſame kind of fruit, he ſoon diſtinguiſhes " them by ſpecific and particular names." This is the logic of all the ſciences, and is very naturally applicable to chemiſtry.

The acids, for example, are compounded of two ſubſtances, which we conſider as ſimple ; the one conſtitutes acidity, and is common to all acids, and, from this ſubſtance, the name of the claſs or the genus ought to be taken ; the other is peculiar to each acid, and diſtinguiſhes it from the reſt, and from this ſubſtance is to be taken the name of the ſpecies. But, in the greater number of acids, theſe two conſtituent elements, the acidifying principle, and that which it acidifies, may exiſt in different proportions, conſtituting all the poſſible points of equilibrium or of ſaturation. This is the caſe in the ſulphur*ic* and the ſulphur*ous* acids ; and theſe two ſtates of the ſame acid we have marked by varying the termination of the ſpecific name.

Metallic ſubſtances which have been expoſed to

to the joint aƈtion of the air and of fire, loſe their metallic luſtre, increaſe in weight, and aſſume an earthy appearance. In this ſtate, like the acids, they are compounded of a principle which is common to all, and of one which is peculiar to each. In the ſame way, therefore, we have thought proper to claſs them under a generic name, derived from the common principle; for which purpoſe, we have adopted the term *oxyd;* and we diſtinguiſh them from each other by the particular name of the metal to which each belongs.

Combuſtible ſubſtances, which in acids and metallic oxyds are ſpecific and particular principles, are capable of becoming, in their turn, common principles of a great number of compounds. The ſulphurous combinations have been long the only known ones in this kind: Now, however, we know, from the experiments of Meſſrs Vandermonde, Monge, and Berthollet, that carbon may be combined with iron, and perhaps with ſeveral other metals; and that, from this combination, according to the proportions, may be produced ſteel, plumbago, &c. We know likewiſe, from the experiments of M. Pelletier, that phoſphorus may be combined with

a great number of metallic ſubſtances. Theſe different combinations we have claſſed under generic names taken from the common ſubſtance, with a termination which marks this analogy, ſpecifying them by another name taken from that ſubſtance which is proper to each.

The nomenclature of bodies compounded of three ſimple ſubſtances was attended with ſtill greater difficulty; not only on account of their number, but particularly, becauſe we cannot expreſs the nature of their conſtituent principles without employing more compound names. In the bodies which form this claſs, ſuch as the neutral ſalts, for inſtance, we had to conſider, 1ſt, The acidifying principle which is common to them all; 2d, The acidifiable principle which conſtitutes their peculiar acid; 3d, The ſaline, earthy, or metallic baſis, which determines the particular ſpecies of ſalt. Here we derived the name of each claſs of ſalts from the name of the acidifiable principle common to all the individuals of that claſs; and diſtinguiſhed each ſpecies by the name of its peculiar ſaline, earthy, or metallic baſis.

A ſalt, though compounded of the ſame three

principles, may, neverthelefs, by the mere difference of their proportion, be in three different ftates of faturation. The nomenclature we have adopted would have been defective, had it not expreffed thefe different ftates; and this we attained chiefly by changes of termination uniformly applied to the fame ftate of the different falts.

In fhort, we have advanced fo far, that from the name alone may be inftantly found; what the combuftible fubftance is which enters into any combination; whether that combuftible fubftance be combined with the acidifying principle, and in what proportion; what is the ftate of the acid; with what bafis it is united; whether the faturation be exact, or whether the acid or the bafis be in excefs.

It may eafily be fuppofed that it was not poffible to attain all thefe different objects without departing, in fome inftances, from eftablifhed cuftom, and adopting terms which, at firft fight, may appear uncouth and barbarous. But we confidered that the ear is foon habituated to new words, efpecially when they are connected with a general and rational fyftem. The names, befides,

besides, which were formerly employed, such as *powder of algaroth*, *salt of alembroth*, *pompholix*, *phagadenic water*, *turbith mineral*, *colcothar*, and many others, were neither less barbarous nor less uncommon. It required a great deal of practice, and no small degree of memory, to recollect the substances to which they were applied; much more to recollect the genus of combination to which they belonged. The names of *oil of tartar per diliquium*, *oil of vitriol*, *butter of arsenic*, *and of antimony*, *flowers of zinc*, &c. were still more improper, because they suggested false ideas; for, in the whole mineral kingdom, and particularly in the metallic class, there exists no such thing as butters, oils, or flowers; in short, the substances to which these fallacious names were given, are rank poisons.

When we published our essay on the Nomenclature of Chemistry, we were reproached for having changed the language which was spoken by our masters, which they stamped with their authority, and have handed down to us. But those who reproach us on this account, have forgotten that Bergman and Macquer urged us to make this reformation: In a letter which the learned Professor of Upsal, M. Bergman, wrote,

a ſhort time before he died, to Mr Morveau, he bids him *ſpare no improper names ; thoſe who are learned, will always be learned, and thoſe who are ignorant will thus learn ſooner.*

There is an objection to this work, which is perhaps better founded ; that I have given no account of the opinions of thoſe who have gone before me, and have only ſtated my own, without examining thoſe of others. By this I have been prevented from doing that juſtice to my aſſociates, and more eſpecially to foreign chemiſts, which I wiſhed to render them. But I beſeech the reader to conſider, that, if I had filled an elementary work with a multitude of quotations, if I had allowed myſelf to enter into long diſſertations on the hiſtory of the ſcience, and the works of thoſe who have ſtudied it, I muſt have loſt ſight of the true object I had in view, and ſhould have produced a work extremely tireſome to beginners.

It is not the hiſtory of the ſcience, or of the human mind, that we are to attempt in an elementary treatiſe. Our only aim ſhould be eaſe and perſpicuity, and with the utmoſt care to keep every thing out of view which may draw aſide the attention of the ſtudent. It is a road which

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we ſhould be continually rendering more ſmooth, and from which we muſt endeavour to remove every obſtacle which can occaſion delay. The ſciences, from their own nature, preſent a ſufficient number of difficulties, though we add not thoſe which are foreign. But, beſides this, chemiſts will eaſily perceive, that, in the firſt part of my work, I make very little uſe of any experiments but thoſe which were made by myſelf. If at any time I have adopted, without acknowledgment, the experiments or the opinions of M. Berthollet, M. Fourcroy, M. de la Place, M. Monge, or, in general, of any of thoſe whoſe principles are the ſame with my own, it is owing to this circumſtance, that frequent intercourſe, and the habit of communicating our ideas, our obſervations, and our ways of thinking, to each other, has eſtabliſhed between us a ſort of community of opinions, in which it is often difficult for every one to know his own.

Theſe remarks on the order which I thought myſelf obliged to follow in the arrangement of proofs and ideas, are to be applied only to the firſt part of this work. It is the only one which contains the general ſum of the doctrine I have adopted, and to which I wiſhed to give a form completely elementary.

The ſecond part is compoſed chiefly of tables of the nomenclature of the neutral ſalts. To theſe I have only added general explanations, the object of which is to point out the moſt ſimple proceſſes for obtaining the different kinds of known acids. This part contains nothing which I can call my own, and preſents only a very ſhort abridgment of the reſults of theſe proceſſes, extracted from the works of different authors.

In the third part, I have given a deſcription, in detail, of all the operations connected with modern chemiſtry. I have long thought that a work of this kind was much wanted, and I am convinced it will not be without its uſe. The method of performing experiments, and particularly thoſe of modern chemiſtry, is not ſo generally known as it ought to be; and had I, in the different memoirs which I have preſented to the Academy, been more particular in the detail of the manipulations of my experiments, it is probable I ſhould have made myſelf better underſtood, and the ſcience might have made a more rapid progreſs. The order for the different matters contained in this third part appears to me almoſt arbitrary; and the only one I have obſerved is to claſs together, in each of the chapters

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of which it is compofed, thofe operations which are moft connected with one another. I need hardly mention, that this part could not be borrowed from any other work, and that, in the principal articles it contains, I could not derive affiftance from any thing but the experiments which I have made myfelf.

I fhall conclude this preface by tranfcribing, literally, fome obfervations of the Abbé de Condillac, which I think defcribe, with a good deal of truth, the ftate of Chemiftry at a period not far diftant from our own. Thefe obfervations were made on a different fubject; but they will not on this account, have lefs force, if the application of them be juft.

" Inftead of applying obfervation to the things
" we wifhed to know, we have chofen rather to
" imagine them. Advancing from one ill-found-
" ed fuppofition to another, we have at laft be-
" wildered ourfelves amid a multitude of errors.
" Thefe errors, becoming prejudices, are, of
" courfe, adopted as principles, and we thus be-
" wilder ourfelves more and more. The method,
" too, by which we conduct our reafonings is
" abfurd; we abufe words which we do not un-
" derftand, and call this the art of reafoning.
" When matters have been brought this length,

" when errors have been thus accumulated, there
" is but one remedy, by which order can be re-
" ſtored to the faculty of thinking; this is, to
" forget all that we have learned, to trace back
" our ideas to their ſource, to follow the train in
" which they riſe, and, as Lord Bacon ſays, to
" frame the human underſtanding anew.

" This remedy becomes the more difficult, in
" proportion as we think ourſelves the more
" learned. Might it not be thought, that works
" which treat of the ſciences with the utmoſt per-
" ſpicuity, and with the greateſt order and pre-
" ciſion, muſt be underſtood by every body?
" The fact is, thoſe who have never ſtudied any
" thing will underſtand them better than thoſe
" who have ſtudied a great deal, and eſpecially
" than thoſe who have written a great deal."

In another place the Abbé de Condillac adds:
" But, notwithſtanding, the ſciences have impro-
" ved, becauſe philoſophers have applied them-
" ſelves with more attention than formerly to ob-
" ſerve Nature, and have communicated to their
" language that preciſion and accuracy which
" they have employed in their obſervations.—By
" correcting their language they have reaſoned
" better."

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OF

CHEMISTRY.

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CHAP. I.

Of the Combinations of Caloric, and the Formation of Elaſtic Aëriform Fluids.

THAT every body, whether ſolid or fluid, is augmented in all its dimenſions by any increaſe of its ſenſible heat, was long ago fully eſtabliſhed as a phyſical axiom, or univerſal propoſition, by the celebrated Boerhaave. Such facts as have been adduced for controverting the

generality of this principle, offer only fallacious results, or, at least, such as are so complicated with foreign circumstances, as to mislead the judgment. But, when we separately consider the effects, so as to deduce each from the cause to which they separately belong, it is easy to perceive, that the separation of particles by heat is a constant and general law of nature.

When we have heated a solid body to a certain degree, and have thereby caused its particles to separate from each other, if we allow the body to cool, its particles again approach each other, in the same proportion in which they were separated by the increased temperature; the body returns by the same degrees of expansion through which it before extended; and, if brought back to the same temperature which it possessed at the commencement of the experiment, it recovers exactly the same dimensions which it formerly occupied. We are still very far from being able to produce the degree of absolute cold, or total deprivation of heat, being unacquainted with any degree of coldness which we cannot suppose capable of still further augmentation; hence it follows, that we are incapable of causing the ultimate particles of bodies to approach each other as near as possible, and that these particles of bodies do not touch each other in any state hitherto known. Though

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this be a very ſingular concluſion, it is impoſſible to be denied.

It may be ſuppoſed, that, ſince the particles of bodies are thus continually impelled by heat to ſeparate from each other, they would have no connection between themſelves; and that, of conſequence, there could be no ſolidity in nature, unleſs theſe particles were held together by ſome other power which tended to unite them, and, ſo to ſpeak, to chain them together: This power, whatever be its cauſe, or manner of operation, is named Attraction.

Thus the particles of all bodies may be conſidered as ſubject to the action of two oppoſite powers, Repulſion and Attraction, between which they remain in equilibrio. So long as the attractive force remains ſtronger, the body muſt continue in a ſtate of ſolidity; but if, on the contrary, heat has ſo far removed theſe particles from each other as to place them beyond the ſphere of attraction, they loſe the coheſion they before had with each other, and the body ceaſes to be ſolid.

Water gives us a regular and conſtant example of theſe facts. While its temperature is below 32° of Fahrenheits ſcale*, it remains ſolid, and

* Whenever the degree of heat occurs in the original, it is ſtated by the author according to Reaumur's thermometer;

and is called ice. Above that degree of temperature, its particles being no longer held together by reciprocal attraction, it becomes liquid; and, when we raife its temperature above 212°, its particles, giving way to the repulfion caufed by the heat, affume the ftate of vapour or gas, and the water is changed into an aëriform fluid.

The fame may be affirmed of all bodies in nature: They are either folid, or liquid, or in the ftate of elaftic aëriform vapour, according to the proportion which takes place between the attractive force inherent in their particles, and the repulfive power of the heat acting upon thefe; or, what amounts to the fame thing, in proportion to the degrees of heat to which they are expofed.

It is difficult to comprehend thefe phenomena, without admitting them as the effects of a real and material fubftance, or very fubtile fluid, which, infinuating itfelf between the particles of bodies, feparates them from each other. Even allowing that the exiftence of this fluid may be hypothetical, we fhall fee in the fequel that it explains the phenomena of nature in a very fatisfactory manner.

This fubftance, whatever it is, being the caufe of

mometer; but the tranflator has thought it more convenient to ufe Fahrenheits fcale, as more generally employed and underftood in Britain.—T.

of heat, or, in other words, the ſenſation which we call *warmth* being cauſed by the accumulation of this ſubſtance, we cannot, in ſtrict language, diſtinguiſh it by the term *heat*, becauſe the ſame name would then very improperly expreſs both cauſe and effect. For this reaſon, in the memoir which I publiſhed in 1777 *, I gave it the names of *igneous fluid* and *matter of heat*: And, ſince that time, in the work † publiſhed by Mr de Morveau, Mr Berthollet, Mr de Fourcroy, and myſelf, upon the reformation of chemical nomenclature, we thought it neceſſary to reject all periphraſtic expreſſions, which both lengthen phyſical language, and render it leſs diſtinct, and which even frequently do not convey ſufficiently juſt ideas of the object intended. Wherefore, we have diſtinguiſhed the cauſe of heat, or that exquiſitely elaſtic fluid which produces it, by the term of *caloric*. Beſides that this expreſſion fulfils our object in the ſyſtem which we have adopted, it poſſeſſes this farther advantage, that it accords with every ſpecies of opinion; ſince, ſtrictly ſpeaking, we are not obliged to ſuppoſe this to be a real ſubſtance, it being ſufficient, as will more clearly appear in the ſequel of this work, that it be conſidered as the

 repulſive

* Collections of the French Academy of Sciences for that year, p. 420.

† New Chemical Nomenclature.

repulſive cauſe, whatever that may be, which ſeparates the particles of matter from each other; ſo that we are ſtill at liberty to inveſtigate its effects in an abſtract and mathematical manner.

In the preſent ſtate of our knowledge, we are unable to determine whether light be a modification of caloric, or if caloric be, on the contrary, a modification of light. This, however, is indiſputable, that in a ſyſtem where only decided facts are admiſſible, and where we avoid, as far as poſſible, to ſuppoſe any thing to be, that is not really known to exiſt, we ought proviſionally to diſtinguiſh, by diſtinct terms, ſuch things as are known to produce different effects. We therefore diſtinguiſh light from caloric; though we do not therefore deny that theſe have certain qualities in common, and that, in certain circumſtances, they combine with other bodies almoſt in the ſame manner, and produce, in part, the ſame effects.

What I have already ſaid may ſuffice to determine the idea affixed to the word *caloric;* but there remains a more difficult attempt, which is, to give a juſt conception of the manner in which caloric acts upon other bodies. Since this ſubtile matter penetrates through the pores of all known ſubſtances; ſince there are no veſſels through which it cannot eſcape; and, conſequently, as there are none which are capable of retaining it; we can only come at the

knowledge

knowledge of its properties by effects which are fleeting and difficultly afcertainable. It is in thofe things which we neither fee nor feel, that it is efpecially neceffary to guard againft the extravagancy of our imagination, which for ever inclines to ftep beyond the bounds of truth, and is very difficultly reftrained within the narrow limits of facts.

We have already feen, that the fame body becomes folid, or fluid, or aëriform, according to the quantity of caloric by which it is penetrated; or, more ftrictly, according as the repulfive force exerted by the caloric is equal to, ftronger, or weaker, than the attraction of the particles of the body it acts upon.

But, if thefe two powers only exifted, bodies would become liquid at an indivifible degree of the thermometer, and would almoft inftantaneoufly pafs from the folid ftate of aggregation to that of aëriform elafticity. Thus water, for inftance, at the very inftant when it ceafes to be ice, would begin to boil, and would be tranfformed into an aëriform fluid, having its particles fcattered indefinitely through the furrounding fpace. That this does not happen, muft depend upon the action of fome third power: The Preffure of the Atmofphere prevents this feparation, and caufes the water to remain in the liquid ftate until raifed to the temperature indicated by 212° on the fcale of Fahrenheits thermometer;

meter; the quantity of caloric which it receives in the lower temperatures being insufficient to overcome the pressure of the atmosphere.

Whence it appears, that, without this atmospheric pressure, we should not have any permanent liquid, and should only see bodies in that state of existence in the very instant of melting; for the smallest additional caloric would then instantly separate their particles, and dissipate them through the surrounding medium. Besides, without this atmospheric pressure, we should not even have any proper aëriform fluids; because the moment the force of attraction is overcome by the repulsive power of the caloric, the particles of bodies would separate themselves indefinitely, having nothing to give limits to their expansion, unless their own gravity might collect them together, so as to form an atmosphere.

Simple reflection, upon the most common experiments, is sufficient to evince the truth of these positions. They are more particularly proved by the following experiment, which I published in the Memoirs of the French Academy of Sciences for 1777, p. 426.

Having filled with Sulphuric Ether * a small narrow

* I shall afterwards give a definition, and explain the properties, of the liquor called *Ether*; I shall therefore only premise

narrow glafs veffel, A, (Plate VII. Fig. 17.), ftanding upon its ftalk P; the veffel, which is from twelve to fifteen lines diameter, is covered by a wet bladder, tied round its neck with feveral turns of ftrong thread; for greater fecurity, a fecond bladder is fixed over the firft. The veffel fhould be filled in fuch a manner with the ether, as not to leave the fmalleft portion of air between the liquor and the bladder. It is now placed under the recipient BCD of an air-pump, of which the upper part B is fitted with a leathern collar, through which paffes a wire EF, having its point F very fharp; and in the fame receiver there is placed the barometer GH. The whole being thus difpofed, let the recipient be exhaufted, and then, by pufhing down the wire EF, a hole is made in the bladder: Immediately the ether begins to boil with great violence, and is changed into an elaftic aëriform fluid, which fills the receiver. If the quantity of ether be fufficient to leave a few drops in the phial after the evaporation is finifhed, the elaftic fluid produced will fuftain the mercury in the barometer attached to the air-pump, at eight or ten inches in winter, and from twenty to twenty-five

premife here, that it is a very volatile and highly inflammable liquor, having a confiderably fmaller fpecific gravity than water, or even fpirit of wine.—A.

five in ſummer *. To render this experiment more complete, we may introduce a ſmall thermometer into the phial A, containing the ether, which will be found to deſcend conſiderably during the evaporation.

The only effect produced in this experiment is, the taking away the weight of the atmoſphere, which, in its ordinary ſtate, preſſes on the ſurface of the ether; and the effects reſulting from this removal evidently prove, that, in the ordinary temperature of the earth, ether would always exiſt in an aëriform ſtate, but for the preſſure of the atmoſphere, and that the change of the ether from the liquid to the aëriform ſtate is accompanied by a conſiderable diminution of temperature; becauſe, during the evaporation, a part of the caloric, which was before in a free ſtate, or at leaſt in equilibrio † in the ſurrounding bodies, combines with the ether, and cauſes it to aſſume the aëriform ſtate.

The ſame experiment ſucceeds with all evaporable

* It would have been more ſatisfactory if the Author had ſpecified the degrees of the thermometer at which theſe heights of the mercury in the barometer are produced.—T.

† I ſhould rather ſuppoſe, according to Mr Lavoiſiers own principles, that the evaporation is produced in conſequence of the equilibrium between the repulſive force of the caloric contained in the ether, and the reſiſtance to expanſion exerted by the atmoſpheric preſſure being removed.—T.

porable fluids, ſuch as alcohol, water, and even mercury; with this difference, that the atmoſphere, formed in the receiver by alcohol, only ſupports the attached barometer about one inch in winter, and about four or five inches in ſummer; that formed by water, in the ſame ſituation, raiſes the mercury only a few lines; and that produced by quickſilver raiſes it but a few fractions of a line. There is therefore leſs fluid evaporated from alcohol than from ether, leſs from water than from alcohol, and ſtill leſs from mercury than from either; conſequently there is leſs caloric employed, and leſs cold produced, which quadrates exactly with the reſults of theſe experiments.

Another ſpecies of experiment proves very evidently, that the aëriform ſtate is a modification of bodies dependent on the degree of temperature, and on the preſſure which theſe bodies undergo. In a Memoir read by Mr de la Place and myſelf to the Academy in 1777, which has not been printed, we have ſhewn that, when ether is ſubjected to a preſſure equal to twenty-eight inches of the barometer, or about the medium preſſure of the atmoſphere, it boils at the temperature of about 104°, or 106.25° of the thermometer. Mr de Luc, who has made ſimilar experiments with ſpirit of wine, finds it to boil at 182.75°: And it is well known that water boils at 212°. Now, boiling being only the evaporation of a liquid,

liquid, or the moment of its paſſing from the fluid to the aëriform ſtate, it is evident that, if we keep ether continually at or above the temperature of 106.25°, and under the common preſſure of the atmoſphere, we ſhall have it always in an elaſtic aëriform ſtate; and that the ſame thing will happen with alcohol when above 182.75°, and with water when above 212°; all which are perfectly conformable to the following experiment *.

I filled a large veſſel A B C D (Plate VII. Fig. 15.) with water, at 110.75°, or 113°: I ſuppoſe the veſſel tranſparent, that we may ſee what takes place in the experiment; and we can eaſily hold the hands in water at that temperature without inconvenience. Into this veſſel I plunged ſome narrow-necked bottles F, G, filled with the water and turned up, ſo as to reſt on their mouths on the bottom of the veſſel. Having next put ſome ether into a very ſmall matraſs, with its neck, *a b c*, twice bent as in the plate, I plunged this matraſs into the water, having its neck inſerted into the mouth of one of the bottles F. Immediately on feeling the effects of the heat, communicated to it by the water in the veſſel ABCD, the ether began to boil, and the caloric, entering into combination with it, changed it into

* Vide Memoirs of the French Academy, anno 1780, p. 335.—A.

to an elaftic aëriform fluid, with which I filled feveral bottles fucceffively, F, G, &c.

This is not the place to énter upon the examination of the nature and properties of this aëriform fluid, which is extremely inflammable; but, confining myfelf to the object at prefent in view, without anticipating circumftances, which I am not to fuppofe the reader to know, I fhall only obferve, that the ether, from this experiment, is almoft only capable of exifting in the aëriform ftate in our ufual temperatures; for, if the weight of our atmofphere was only equal to between 20 and 24 inches of the barometer, inftead of 28 inches, we fhould never be able to obtain ether in the liquid ftate, at leaft in fummer. The preparation of ether would confequently be impoffible upon mountains of a moderate degree of elevation, as it would be converted into gas immediately upon being produced, unlefs we employed recipients of extraordinary ftrength, affifted by refrigeration and compreffion. And, laftly, the temperature of the blood being nearly that at which ether paffes from the liquid to the aëriform ftate, it muft evaporate in the primæ viæ, and confequently it is very probable that the medical properties of this fluid depend chiefly upon its mechanical effect.

Thefe experiments fucceed better with nitrous ether, becaufe it evaporates in a lower temperature than fulphuric ether. It is more difficult

to

to obtain alcohol in the aëriform ſtate; becauſe, as it requires a temperature of 182.75° to raiſe it to vapour, the water of the bath muſt be almoſt boiling, and it is impoſſible to plunge the hands into it at that temperature.

It is evident that, if water were uſed in the foregoing experiment, it would be changed into gas, when expoſed to a temperature ſuperior to that at which it boils: Although thoroughly convinced of this, Mr de la Place and myſelf judged it neceſſary to confirm it by the following direct experiment. We filled a glaſs-jar, A, (Plate VII. Fig. 5.) with mercury, and placed it, with its mouth downwards, in a diſh, B, likewiſe filled with mercury, and introduced about two drams of water into the jar, which roſe to the top of the mercury at CD; we then plunged the whole apparatus into an iron boiler, EFGH, full of boiling ſea-water, of the temperature of 223.25°, placed upon the furnace GHIK. So ſoon as the water over the mercury reached the temperature of 212°, it began to boil; and inſtead of only filling the ſmall ſpace ACD, it was converted into an aëriform fluid, which filled the whole jar; the mercury even deſcended below the ſurface of that in the diſh B; and the jar muſt have been overturned, if it had not been very thick and heavy, and fixed to the diſh by means of iron-wire. Immediately after withdrawing the apparatus from the boiler,

er, the vapour in the jar began to condenſe, and the mercury roſe to its former ſtation; but the water returned again to the aëriform ſtate in a few ſeconds after replacing the apparatus in the boiler.

We have thus a certain number of ſubſtances, which are convertible into elaſtic aëriform fluids, by degrees of temperature not much ſuperior to that of our atmoſphere. We ſhall afterwards find that there are ſeveral others which undergo the ſame change in ſimilar circumſtances, ſuch as muriatic or marine acid, ammoniac or volatile alkali, the carbonic acid or fixed air, the ſulphurous acid, &c. All theſe are permanently elaſtic in or about the mean temperature of the atmoſphere, and under its common preſſure.

All theſe facts, which could be eaſily multiplied, if neceſſary, give full right to aſſume, as a general principle, that almoſt every body in nature is ſuſceptible of three ſeveral ſtates of exiſtence, ſolid, liquid, and aëriform; and that theſe three ſtates of exiſtence depend upon the quantity of caloric combined with the body. Henceforward I ſhall expreſs theſe elaſtic aëriform fluids by the generic term *gas*; and in each ſpecies of gas I ſhall diſtinguiſh between the caloric, which in ſome meaſure ſerves the purpoſe of a ſolvent, and the ſubſtance, which, in combination with the caloric, forms the baſe of the gas.

To

To theſe baſes of the different gaſes, which are hitherto but little known, we have been obliged to aſſign names: Theſe ſhall be enumerated in Chap. IV. of this work, when I have previouſly given an account of the phenomena attendant upon the heating and cooling of bodies, and when I have eſtabliſhed preciſe ideas concerning the compoſition of our atmoſphere.

We have already ſhewn, that the particles of every ſubſtance in nature exiſt in a certain ſtate of equilibrium, between that attraction which tends to unite and keep the particles together, and the effects of the caloric which tends to ſeparate them. Hence, caloric not only ſurrounds the particles of all bodies on every ſide, but fills up every interval which the particles of bodies leave between each other. We may form an idea of this, by ſuppoſing a veſſel filled with ſmall ſpherical leaden bullets, among which a quantity of fine ſand is poured; this, inſinuating itſelf into the intervals between the bullets, will fill up every void. The balls, in this compariſon, are to the ſand which ſurrounds them exactly in the ſame ſituation as the particles of bodies are with reſpect to the caloric; with this difference only, that the balls are ſuppoſed to touch each other, whereas the particles of bodies are not in contact, being retained at a ſmall diſtance from each other by the caloric.

If

If, inſtead of ſpherical balls, we ſubſtitute ſolid bodies of a hexahedral, octohedral, or any other regular figure, the capacity of the intervals between them will be leſſened, and conſequently will no longer contain the ſame quantity of ſand. The ſame thing takes place with reſpect to natural bodies; the intervals left between their particles are not of equal capacity, but vary in conſequence of the different figures and magnitude of their particles, and of the diſtance at which theſe particles are maintained, according to the exiſting proportion between their inherent attraction, and the repulſive force exerted upon them by the caloric.

In this manner we muſt underſtand the following expreſſion, introduced by the Engliſh philoſophers, who have given us the firſt preciſe ideas upon this ſubject; *the capacity of bodies for containing the matter of heat.* As compariſons with ſenſible objects are of great uſe in aſſiſting us to form diſtinct notions of abſtract ideas, I ſhall endeavour to illuſtrate this, by inſtancing the phenomena which take place between water and bodies which are wetted and penetrated by it, with a few reflections.

If equal pieces of different kinds of wood, ſuppoſe cubes of one foot each, be immerſed in water, the fluid gradually inſinuates itſelf into their pores, and the pieces of wood are augmented both in weight and magnitude: Each

ſpecies of wood will imbibe a different quantity of water; the lighter and more porous woods will admit a larger, the compact and cloſer grained will admit a leſs quantity; for the proportional quantities of water, imbibed by the pieces, will depend upon the nature of the conſtituent particles of the wood, and upon the greater or leſs affinity ſubſiſting between them and water: Very reſinous wood, for inſtance, though it may be at the ſame time very porous, will admit but little water. We may therefore ſay, that different kinds of wood poſſeſs different capacities for receiving water; and we may even determine, by means of the augmentation of their weights, what quantity of water they have actually abſorbed; but, as we are ignorant how much water they contained previous to immerſion, we cannot determine the abſolute quantity they contain after being taken out of the water.

The ſame circumſtances undoubtedly take place with bodies that are immerſed in caloric; taking into conſideration, however, that water is an incompreſſible fluid, whereas caloric is, on the contrary, endowed with very great elaſticity; or, in other words, the particles of caloric have a great tendency to ſeparate from each other, when forced by any other power to approach; this difference muſt of neceſſity occa-

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tion very confiderable diverfities in the refults of experiments made upon thefe two fubftances.

Having eftablifhed thefe clear and fimple propofitions, it will be very eafy to explain the ideas which ought to be affixed to the following expreffions, which are by no means fynonymous, but poffefs each a ftrict and determinate meaning, as in the following definitions:

Free caloric, is that which is not combined in any manner with any other body. But, as we live in a fyftem to the matter of which caloric has a very ftrong adhefion, we are never able to obtain it in the ftate of abfolute freedom.

Combined caloric, is that which is fixed in bodies, by affinity or elective attraction, fo as to form part of the fubftance of the body, even part of its folidity.

By the expreffion *fpecific caloric* of bodies, we underftand the refpective quantities of caloric requifite for raifing a number of bodies of the fame weight to an equal degree of temperature. This proportional quantity of caloric depends on the diftance between the conftituent particles of bodies, and their greater or lefs degrees of cohefion; and this diftance, or rather the fpace or void refulting from it, is, as I have already obferved, called the *capacity of bodies for containing caloric*.

Heat, confidered as a fenfation, or, in other words, fenfible heat, is only the effect produced upon our fentient organs, by the motion or paffage of caloric, difengaged from the furrounding bodies. In general, we receive impreffions only in confequence of motion, and it might be eftablifhed as an axiom, *That*, WITHOUT MOTION, THERE IS NO SENSATION. This general principle applies very accurately to the fenfations of heat and cold: When we touch a cold body, the caloric, which always tends to become in equilibrio in all bodies, paffes from our hand into the body we touch, which gives us the feeling or fenfation of cold. The direct contrary happens when we touch a warm body; the caloric, then, in paffing from the body into our hand, produces the fenfation of heat. If the hand and the body touched be of the fame temperature, or very nearly fo, we receive no impreffion, either of heat or cold, becaufe there is no motion or paffage of caloric; and thus no fenfation can take place, without fome correfpondent motion to occafion it.

When the thermometer rifes, it fhows, that free caloric is entering into the furrounding bodies: The thermometer, which is one of thefe, receives its fhare in proportion to its mafs, and to the capacity which it poffeffes for containing caloric. The change, therefore, which takes place upon the thermometer, only announces a change

change of place of the caloric in thofe bodies, of which the thermometer forms one part; it only indicates the portion of caloric received, without being a meafure of the whole quantity difengaged, difplaced, or abforbed.

The moft fimple and moft exact method for determining this latter point, is that defcribed by Mr de la Place, in the Memoirs of the Academy, for the year 1780, p. 364; a fummary explanation of which will be found towards the conclufion of this work. This method confifts in placing a body, or a combination of bodies, from which caloric is difengaging, in the middle of a hollow fphere of ice; and the quantity of ice melted becomes an exact relative meafure of the quantity of caloric difengaged. It is poffible, by means of the apparatus which we have got conftructed upon this plan, to determine, not as has been pretended, the capacity of bodies for containing heat, but the ratio of the increafe or diminution of capacity produced by determinate degrees of temperature. It is eafy, with the fame apparatus, by varioufly combined experiments, to determine the relative quantities of caloric neceffary for converting folid fubftances into liquids, and liquids into elaftic aëriform fluids; and *vice verfâ*, what quantity of caloric efcapes from elaftic vapours in changing to liquids, and what quantity efcapes from liquids during their converfion into folids. Perhaps, when

 experiments

experiments ſhall have been made with ſufficient accuracy, we may one day be able to determine the proportional quantities of caloric neceſſary for producing the ſeveral ſpecies of gaſes. I ſhall hereafter, in a ſeparate chapter, give an account of the principal reſults of ſuch experiments as have been made upon this head.

It remains, before finiſhing this article, to ſay a few words concerning the cauſe of the elaſticity of gaſes, and of liquids in the ſtate of vapour. It is by no means difficult to perceive that this elaſticity depends upon that of caloric, which ſeems to be the moſt eminently elaſtic body in nature. Nothing is more readily conceivable, than that one body ſhould become elaſtic, by entering into combination with another body poſſeſſed of that quality. We muſt allow that this is only an explanation of elaſticity, by an aſſumption of elaſticity; we thus only remove the difficulty one ſtep farther, and the reaſon for caloric being elaſtic, ſtill remains unexplained. Elaſticity in the abſtract is merely a ſuppoſable quality inherent in the particles of bodies, by virtue of which they recede from each other when forced together. This tendency in the particles of caloric to ſeparate, takes place even at conſiderable diſtances. We ſhall be ſatisfied of this, when we conſider that air is capable of undergoing great compreſſion, which ſuppoſes that its particles were previouſly

ly at a confiderable diftance from each other; for the power of approaching together certainly fuppofes a previous diftance, at leaft equal to the degree of approximation: Confequently, thofe particles of the air, which are already confiderably diftant from each other, tend to feparate ftill farther. If we produce Boyles vacuum in a large receiver of an air-pump, the laft portion of air which remains extends itfelf uniformly through the whole capacity of the veffel, however large, filling it completely, and preffing every where againft its fides: We cannot explain this fact, without fuppofing that the particles make an effort to feparate themfelves on every fide; and we are quite ignorant at what diftance, or in what degree of rarefaction, this effort ceafes to act.

In the above experiments a true repulfion takes place between the particles of elaftic fluids; at leaft, circumftances occur exactly as if fuch a repulfion actually exifted: and we have a right to conclude, that the particles of caloric mutually repel each other. When we are once permitted to fuppofe this repelling force, the theory of the formation of gafes, or aëriform fluids, becomes perfectly fimple; though we muft, at the fame time, allow, that it is extremely difficult to form an accurate conception how this repulfive force acts upon very mi-

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nute particles placed at great diſtances from each other.

It is, perhaps, more natural to ſuppoſe, that the particles of caloric have a ſtronger mutual attraction than thoſe of any other ſubſtance, and that theſe latter particles are torn aſunder in conſequence of this ſuperior attraction of the particles of caloric, which forces them between the particles of other bodes, that they may be able to reunite with each other. We may obſerve ſomething analogous to this idea in the phenomena which occur when a dry ſponge is dipt in water: The ſponge ſwells; its particles ſeparate from each other; and all its intervals are filled by the water. It is evident, that the ſponge, in the act of ſwelling, has acquired a greater capacity * for containing water than it had when dry.

* This aſſertion does not ſeem well founded:—That, in the act of ſwelling, the ſponge receives more water than it held when dry, is very evident; and that, in conſequence of its fibres being ſtretched, more room is left between them, is likewiſe true: But if, by capacity for receiving water, we are to underſtand that quality inherent in the ſponge for imbibing water, in conſequence of the diſpoſition and peculiar ſtructure of its parts, this remains the ſame when perfectly dry as when filled completely with moiſture; or, if we conſider its capacity to indicate its diſpoſition for receiving additional water, this muſt be greateſt when perfectly dry, and muſt diminiſh in proportion as the water is received into its interſtices.—T.

dry. But we cannot certainly maintain, that the introduction of water between the particles of the ſponge has endowed them with a repulſive power, which tends to ſeparate them from each other; on the contrary, the whole phenomena are produced by means of attractive powers: Theſe are, the gravity of the water, and the power which it exerts on every ſide, in common with all other fluids; The force of attraction which takes place between the particles of the water, cauſing them to unite together; The mutual attraction of the particles of the ſponge for each other; and, The reciprocal attraction which exiſts between the particles of the ſponge and thoſe of the water. It is eaſy to underſtand, that the explanation of this fact depends upon properly appreciating the intenſity of, and connection between, theſe ſeveral powers. It is probable, therefore, that the ſeparation of the particles of bodies, occaſioned by caloric, depends in a ſimilar manner upon a certain combination of different attractive powers, which, in conformity with the imperfection of our knowledge, we endeavour to expreſs by ſaying, that caloric communicates a power of repulſion to the particles of bodies.

CHAP.

CHAP. II.

General Views concerning the Formation and Composition of our Atmosphere.

THESE views which I have taken of the formation of elaſtic aëriform fluids or gaſes, throw great light upon the original formation of the atmoſpheres of the planets, and particularly of that of our earth. We readily conceive that it muſt neceſſarily conſiſt of a mixture of the following ſubſtances: Of all bodies that are ſuſceptible of evaporation, or, more ſtrictly ſpeaking, which are capable of retaining the ſtate of aëriform elaſticity in the temperature of our atmoſphere, and under a preſſure equal to that of a column of twenty-eight inches of quickſilver in the barometer; and, of all ſubſtances, whether liquid or ſolid, which are capable of being diſſolved in this mixture of different gaſes.

To fix our ideas more clearly reſpecting this ſubject, which has not been hitherto ſufficiently conſidered, let us, for a moment, conceive what change would take place in the various ſubſtances

ſubſtances which compoſe our earth, if its temperature were ſuddenly altered. If, for inſtance, we were ſuddenly tranſported to the region of the planet Mercury, where probably the common temperature is much ſuperior to that of boiling water; the water of our world, and all the other fluids which are ſuſceptible of the gaſeous ſtate, at a temperature near to that of boiling water, even quickſilver itſelf, would become rarefied; and all theſe ſubſtances, being changed into permanently aëriform fluids or gaſes, would become part of the new atmoſphere. Theſe new ſpecies of airs or gaſes would mix with thoſe already exiſting, and certain reciprocal decompoſitions and new combinations would take place, until ſuch time as all the elective attractions or affinities ſubſiſting among all theſe new and old gaſeous ſubſtances had operated fully; after which, the elementary principles compoſing theſe gaſes, being ſaturated, would remain at reſt.

We muſt attend to this, however, that, even in the above hypothetical ſituation, certain bounds would occur to the evaporation of theſe ſubſtances, produced by means of that very evaporation itſelf: For as, in proportion to the increaſe of elaſtic fluids, the preſſure of the atmoſphere would be augmented; as every degree of preſſure tends, in ſome meaſure, to prevent evaporation; and as even the moſt evaporable

porable fluids can refift the operation of a very high temperature without evaporating, if prevented by a proportionally ftronger compreffion, water and all other liquids being able to fuftain a red heat in Papins digefter; we muft admit, that the new atmofphere would at laft acquire fuch a degree of weight, that the water which had not hitherto evaporated would ceafe to boil, and, of confequence, would remain liquid. Hence, even upon this fuppofition, as in all others of the fame nature, the increafing gravity of the atmofphere would find certain limits which it could not exceed.

We might extend thefe reflections greatly farther, and examine what change would be produced in fuch fituations upon ftones, falts, and the greater part of the fufible fubftances which compofe the mafs of our earth. Thefe would be foftened, fufed, and changed into liquids, &c. But thefe fpeculations carry me from my object, to which I haften to return.

By a contrary fuppofition to the one we have been forming, if the earth were fuddenly tranfported into a very cold region, the water, which at prefent compofes our feas, rivers, and fprings, and probably the greater number of the fluids we are acquainted with, would be converted into folid mountains and hard rocks, at firft diaphanous and homogeneous, like rock-

cryftal,

cryſtal, but which, in time, becoming mixed with foreign and heterogeneous ſubſtances, would become opaque ſtones of various colours. In this caſe, the air, or, at leaſt, ſome of the aëriform fluids which now compoſe the maſs of our atmoſphere, would doubtleſs loſe their elaſticity, for want of a ſufficient temperature to retain them in that ſtate: They would return to the liquid ſtate of exiſtence *, and new liquids would be formed, of whoſe properties we cannot, at preſent, form the moſt diſtant idea.

Theſe two oppoſite ſuppoſitions give a diſtinct proof of the following corollaries: That *ſolidity*, *liquidity*, and *aëriform elaſticity*, are only three different ſtates of exiſtence of the ſame matter, or three particular modifications which almoſt all ſubſtances are ſuſceptible of aſſuming ſucceſſively, and which ſolely depend on the degree of temperature to which they are expoſed; or, in other words, upon the quantity of caloric with which they are penetrated †: That it is extremely

* Even this ſuppoſition would have its bounds from its own nature: The diminution of preſſure, produced by the decreaſe in the volume, and conſequent gravity, of the atmoſphere, would enable caloric to keep many ſubſtances in the vaporous ſtate, at a much lower degree of temperature than is fit for that purpoſe, under the preſent preſſure of our atmoſphere.—T.

† The degree of preſſure which they undergo muſt be taken into account.—T.

extremely probable that air is a fluid naturally exiſting in a ſtate of vapour; or, as we may better expreſs it, that our atmoſphere is a compound of all the fluids which are ſuſceptible of the vaporous or permanently elaſtic ſtate, in the uſual temperature, and under the common preſſure: That it is not impoſſible we may diſcover, in our atmoſphere, certain ſubſtances naturally very compact, even metals themſelves; as a metallic ſubſtance, for inſtance, only a little more volatile than mercury, might exiſt in that ſituation.

Among the fluids with which we are acquainted, ſome, as water and alcohol, are ſuſceptible of mixing with each other in all proportions; whereas others, as quickſilver, water, and oil, can only form a momentary union, and, after being mixed together, ſeparate and arrange themſelves according to their ſpecific gravities. The ſame ought to, or at leaſt may, take place in the atmoſphere. It is poſſible, and even extremely probable, that, both at the firſt creation, and every day, gaſes are formed, which are difficultly miſcible with atmoſpheric air, and are continually ſeparating from it. If theſe gaſes be ſpecifically lighter than the general atmoſpheric maſs, they muſt, of courſe, gather in the higher regions, and form ſtrata that float upon the common air. The phenomena which accompany

accompany igneous meteors induce me to believe that there exifts, in the upper parts of our atmofphere, a ftratum of inflammable fluid, in contact with thofe ftrata of air in which the phenomena of the aurora borealis and other fiery appearances are produced.—I mean hereafter to purfue this fubject in a feparate treatife.

CHAP.

CHAP. III.

Analyſis of Atmoſpheric Air, and its Diviſion into two Elaſtic Fluids; the one fit for Reſpiration; the other incapable *of being reſpired.*

FROM what has been premiſed, it appears, that our atmoſphere is compoſed of a mixture of every ſubſtance capable of retaining the gaſeous or aëriform ſtate in the common temperatures, and under the uſual degrees of preſſure which it experiences. Theſe fluids conſtitute a maſs, in ſome meaſure homogeneous, extending from the ſurface of the earth to the greateſt height hitherto attained, of which the denſity continually decreaſes in the inverſe ratio of the ſuperincumbent weight. But, as I have before obſerved, it is poſſible that this firſt ſtratum may be ſurmounted by ſeveral others conſiſting of different fluids.

Our buſineſs, in this place, is to endeavour to determine, by experiments, the nature of the elaſtic fluids which compoſe the inferior ſtratum of air which we inhabit. Modern chemiſtry has made great advances in this reſearch; and it will appear, by the following details, that the analyſis of atmoſpherical air has been more rigorouſly

rigorously determined than that of any other subſtance of the claſs.

Chemiſtry affords two general methods of determining the conſtituent principles of bodies, the method of analyſis, and that of ſyntheſis. When, for inſtance, by combining water with alcohol, we form the ſpecies of liquor called, in commercial language, brandy, or ſpirit of wine, we certainly have a right to conclude, that brandy, or ſpirit of wine, is compoſed of alcohol combined with water. We can procure the ſame reſult by the analytical method; and in general it ought to be conſidered as a principle in chemical ſcience, never to reſt ſatisfied without both theſe ſpecies of proofs. We have this advantage in the analyſis of atmoſpherical air; being able both to decompound it, and to form it anew in the moſt ſatisfactory manner. I ſhall, however, at preſent confine myſelf to recount ſuch experiments as are moſt concluſive upon this head; and I may conſider moſt of theſe as my own, having either firſt invented them, or having repeated thoſe of others, intended for analyzing atmoſpherical air, in perfectly new points of view.

I took a matraſs of about 36 cubical inches capacity, having a long neck of ſix or ſeven lines internal diameter, and having bent the neck, as in Plate IV. Fig, 2. B C D E, to allow of its be-

ing placed in the furnace M M N N, in ſuch a manner that the extremity of its neck E might be inſerted under a bell-glaſs F G, placed in a trough of quickſilver R R S S; I introduced four ounces of pure mercury into the matraſs, and, by means of a ſyphon, exhauſted the air in the receiver F G, ſo as to raiſe the quickſilver to L L, and I carefully marked the height at which it ſtood, by paſting on a ſlip of paper. Having accurately noted the height of the thermometer and barometer, I lighted a fire in the furnace M M N N, which I kept up almoſt continually during twelve days, ſo as to keep the quickſilver always very near its boiling point. Nothing remarkable took place during the firſt day: The mercury, though not boiling, was continually evaporating, and covered the interior ſurface of the veſſel with ſmall drops, which gradually augmenting to a ſufficient ſize, fell back into the maſs at the bottom of the veſſel. On the ſecond day, ſmall red particles began to appear on the ſurface of the mercury; theſe, during the four or five following days, gradually increaſed in ſize and number, after which they ceaſed to increaſe in either reſpect. At the end of twelve days, ſeeing that the calcination of the mercury did not at all increaſe, I extinguiſhed the fire, and allowed the veſſels to cool. The bulk of air in the body and neck of the matraſs, and in the bell-glaſs,

glaſs, reduced to a medium of 28 inches of the barometer and 54.5° of the thermometer, at the commencement of the experiment was about 50 cubical inches. At the end of the experiment the remaining air, reduced to the ſame medium preſſure and temperature, was only between 42 and 43 cubical inches; conſequently it had loſt about $\frac{1}{6}$ of its bulk. Afterwards, having collected all the red particles, formed during the experiment, from the running mercury in which they floated, I found theſe to amount to 45 grains.

I was obliged to repeat this experiment ſeveral times, as it is difficult, in one experiment, both to preſerve the whole air upon which we operate, and to collect the whole of the red particles, or calx of mercury, which is formed during the calcination. It will often happen in the ſequel, that I ſhall, in this manner, give in one detail the reſults of two or three experiments of the ſame nature.

The air which remained after the calcination of the mercury in this experiment, and which was reduced to $\frac{5}{6}$ of its former bulk, was no longer fit either for reſpiration or for combuſtion: animals being introduced into it were ſuffocated in a few ſeconds, and when a taper was plunged into it, it was extinguiſhed, as if it had been immerſed in water.

In the next place, I took the 45 grains of red matter formed during this experiment, which I put into a ſmall glaſs retort, having a proper apparatus for receiving ſuch liquid or gaſeous product, as might be extracted: Having applied a fire to the retort in the furnace, I obſerved that, in proportion as the red matter became heated, the intenſity of its colour augmented. When the retort was almoſt red hot, the red matter began gradually to decreaſe in bulk, and in a few minutes after it diſappeared altogether; at the ſame time 41½ grains of running mercury were collected in the recipient, and 7 or 8 cubical inches of elaſtic fluid, greatly more capable of supporting both reſpiration and combuſtion than atmoſpherical air, were collected in the bell-glaſs.

A part of this air being put into a glaſs-tube of about an inch diameter, ſhewed the following properties: A taper burned in it with a dazzling ſplendour; and charcoal, inſtead of conſuming quietly, as it does in common air, burnt with a flame, attended with a decrepitating noiſe, like phoſphorus, and threw out ſuch a brilliant light that the eyes could hardly endure it. This ſpecies of air was diſcovered almoſt at the ſame time by Dr Prieſtley, Mr Scheele, and myſelf. Dr Prieſtley gave it the name of *dephlogiſticated air*; Mr Scheele called it *empyreal air*; at firſt I named it *highly reſpirable air*, to which

which has ſince been ſubſtituted the term of *vital air*. We ſhall preſently ſee what we ought to think of theſe denominations.

In reflecting upon the circumſtances of this experiment, we readily perceive; that the mercury, during its calcination, abſorbs the ſalubrious and reſpirable part of the air, or, to ſpeak more ſtrictly, the baſe of this reſpirable part; that the remaining air is a ſpecies of mephitis, incapable of ſupporting combuſtion or reſpiration; and, conſequently, that atmoſpheric air is compoſed of two elaſtic fluids of different and oppoſite qualities. As a proof of this important truth, if we recombine theſe two elaſtic fluids, which we have ſeparately obtained in the above experiment, viz. the 42 cubical inches of mephitis, with the 8 cubical inches of highly reſpirable air, we reproduce an air preciſely ſimilar to that of the atmoſphere, and poſſeſſing nearly the ſame power of ſupporting combuſtion and reſpiration, and of contributing to the calcination of metals.

Although this experiment furniſhes us with a very ſimple means of obtaining the two principal elaſtic fluids which compoſe our atmoſphere, ſeparate from each other, yet it does not give us an exact idea of the proportion in which theſe two enter into its compoſition: For the attraction of mercury to its reſpirable part of the air, or rather to its baſe, is not ſufficiently ſtrong to overcome all the circumſtances which

 oppoſe

oppofe this union. Thefe obftacles are the mutual adhefion of the two conftituent parts of the atmofphere for each other, and the elective attraction which unites the bafe of vital air with caloric; in confequence of thefe, when the calcination ends, or is at leaft carried as far as is poffible in a determinate quantity of atmofpheric air, there ftill remains a portion of refpirable air united to the mephitis, which the mercury cannot feparate. I fhall afterwards fhew, that, at leaft in our climate, the atmofpheric air is compofed of refpirable and mephitic airs, in the proportion of 27 and 73; and I fhall then difcufs the caufes of the uncertainty which ftill exifts with refpect to the exactnefs of that proportion.

Since, during the calcination of mercury, air is decompofed, and the bafe of its refpirable part is fixed and combined with the mercury, it follows, from the principles already eftablifhed, that caloric and light muft be difengaged during the procefs. But the two following caufes prevent us from being fenfible of this taking place: As the calcination lafts during feveral days, the difengagement of caloric and light, fpread out in a confiderable fpace of time, becomes extremely fmall for each particular moment of the time, fo as not to be perceptible; and, the operation being carried on by means of fire in a furnace, the heat produced

by

by the calcination itſelf becomes confounded with that proceeding from the furnace. I might add, that the reſpirable part of the air, or rather its baſe, in entering into combination with the mercury, does not part with all the caloric which it contained, but ſtill retains a part of it in the new compound: but the diſcuſſion of this point, and its proofs from experiment, do not belong to this part of our ſubject.

It is, however, eaſy to render this diſengagement of caloric and light evident to the ſenſes, by cauſing the decompoſition of air to take place in a more rapid manner; and for this purpoſe, iron is excellently adapted, as it poſſeſſes a much ſtronger affinity for the baſe of reſpirable air than mercury. The following elegant experiment of Mr Ingenhouz, upon the combuſtion of iron, is well known. Take a piece of fine iron wire, twiſted into a ſpiral, BC, Plate IV. Fig. 17.; fix one of its extremities B into the cork A, adapted to the neck of the bottle DEFG, and fix to the other extremity of the wire C, a ſmall morſel of tinder. Matters being thus prepared, fill the bottle DEFG with air deprived of its mephitic part; then light the tinder, and introduce it quickly, with the wire upon which it is fixed, into the bottle, which you ſtop up with the cork A, as is ſhown in the figure 17. Plate IV. The inſtant the

lighted tinder comes into contact with the vital air, it begins to burn with great intenfity; and, communicating the inflammation to the iron-wire, it likewife takes fire and burns rapidly, throwing out brilliant fparks; thefe fall to the bottom of the veffel in rounded globules, which become black in cooling, but retain a degree of metallic fplendour. The iron thus burnt is more brittle even than glafs, is eafily reduced into powder, and is ftill attractable by the magnet, though not fo powerfully as it was before combuftion. As Mr Ingenhoufz has neither examined the change produced on the iron, nor upon the air by this operation, I have repeated the experiment under different circumftances, in an apparatus adapted to anfwer my particular views, as follows:

Having filled a bell-glafs A, Plate IV. Fig. 3. of about fix pints meafure, with pure air, or the highly refpirable part of air, I tranfported this jar, by means of a very flat veffel, into a quickfilver bath in the bafon BC, taking care to render the furface of the mercury perfectly dry, both within and without the jar, with blotting paper. I then provided a fmall cup of China-ware D, very flat and open, in which I placed fome fmall pieces of iron, turned fpirally, and arranged in fuch a way as feemed moft favourable for the combuftion being communicated to every part. To the end of one of thefe pieces of iron was fixed

fixed a ſmall morſel of tinder, to which was added about the ſixteenth part of a grain of phoſphorus; and, by raiſing the bell-glaſs a little, the china cup, with its contents, were introduced into the pure air. I know that, by this means, ſome common air muſt mix with the pure air in the glaſs; but this, when it is done dexterouſly, is ſo very trifling, as not to injure the ſucceſs of the experiment. This being done, a part of the air was ſucked out from the bell-glaſs, by means of a ſyphon GHI, ſo as to raiſe the mercury within the glaſs to EF; and, to prevent the mercury from getting into the ſyphon, a ſmall piece of paper was twiſted round its extremity. In ſucking out the air, if the motion of the lungs only be uſed, we cannot make the mercury riſe above an inch or an inch and a half; but, by properly uſing the muſcles of the mouth, we can, without difficulty, cauſe it to riſe ſix or ſeven inches.

I next took an iron-wire, MN, Plate IV. Fig. 16. properly bent for the purpoſe, and making it red-hot in the fire, paſſed it through the mercury into the receiver, and brought it in contact with the ſmall piece of phoſphorus attached to the tinder. The phoſphorus inſtantly took fire, which communicated to the tinder, and from that to the iron. When the pieces have been properly arranged, the whole iron burns, even to the laſt particle, throwing

out

out a white brilliant light fimilar to that of Chinefe fireworks. The great heat produced by this combuftion melts the iron into round globules of different fizes, moft of which fall into the China cup; but fome are thrown out of it, and fwim on the furface of the mercury. At the beginning of the combuftion, there is a flight augmentation in the volume of the air in the bell-glafs, from the dilatation caufed by the heat; but, prefently afterwards, a rapid diminution of the air takes place, and the mercury rifes in the glafs, infomuch that, when the quantity of iron is fufficient, and the air operated upon is very pure, almoft the whole air employed is abforbed.

It is proper to remark in this place, that, unlefs in making experiments for the purpofe of difcovery, it is better to be contented with burning a moderate quantity of iron; for, when this experiment is pufhed too far, fo as to abforb much of the air, the cup D, which floats upon the quickfilver, approaches too near the bottom of the bell-glafs; and the great heat produced, which is followed by a very fudden cooling, occafioned by the contact of the cold mercury, is apt to break the glafs: In which cafe, the fudden fall of the column of mercury, which happens the moment the leaft flaw is produced in the glafs, caufes fuch a wave, as throws a great part of the quickfilver from the

bafon,

bafon. To avoid this inconvenience, and to enfure fuccefs to the experiment, one dram and a half of iron is fufficient to burn in a bell-glafs, which holds about eight pints of air. The glafs ought likewife to be ftrong, that it may be able to bear the weight of the column of mercury which it has to fupport.

By this experiment, it is not poffible to determine, at one time, both the additional weight acquired by the iron and the changes which have taken place in the air. If it is wifhed to afcertain what additional weight has been gained by the iron, and the proportion between that and the air abforbed, we muft carefully mark upon the bell-glafs, with a diamond, the height of the mercury, both before and after the experiment. After this, the fyphon, GH, Pl. IV. Fig. 3. guarded, as before, with a bit of paper, to prevent its filling with mercury, is to be introduced under the bell-glafs, having the thumb placed upon the extremity, G, of the fyphon, to regulate the paffage of the air; and by this means the air is gradually admitted, fo as to let the mercury fall to its level. This being done, the bell-glafs is to be carefully removed; the globules of melted iron contained in the cup, and thofe which have been fcattered about, and fwim upon the mercury, are to be accurately collected, and the whole is to be weighed. The iron will be found in that ftate called *martial*

ethiops

ethiops by the old chemifts, poffeffing a degree of metallic brilliancy, very friable, and readily reduced into powder, under the hammer, or with a peftle and mortar. If the experiment has fucceeded well, from 100 grains of iron will be obtained 135 or 136 grains of ethiops, which is an augmentation of 35 *per cent.*

If all the attention has been paid to this experiment which it deferves, the air will be found diminifhed in weight, exactly equal to what the iron has gained. Having therefore burnt 100 grains of iron, which has acquired an additional weight of 35 grains, the diminution of air will be found exactly 70 cubical inches; and it will be fhewn, in the fequel, that the weight of vital air is very near half a grain for each cubical inch; fo that, in effect, the augmentation of weight in the one exactly coincides with the lofs of it in the other.

I fhall obferve here, once for all, that, in every experiment of this kind, the preffure and temperature of the air, both before and after the experiment, muft be reduced by calculation, to a common ftandard of 54° of the thermometer, and 28 inches of the barometer. Towards the end of this work, the manner of performing this very neceffary reduction will be found accurately detailed.

If it be required to examine the nature of the air which remains after this experiment, we muft

muſt operate in a ſomewhat different manner. After the combuſtion is finiſhed, and the veſſels have cooled, we firſt take out the cup, and the burnt iron, by introducing the hand through the quickſilver, under the bell-glaſs; we next introduce ſome ſolution of potaſh, or cauſtic alkali, or of the ſulphuret of potaſh, or ſuch other ſubſtances as are judged proper for examining their action upon the reſiduum of air. I ſhall, in the ſequel, give an account of theſe methods of analyzing air, when I have explained the nature of theſe different ſubſtances, which are only here in a manner incidently mentioned. After this examination, ſo much water muſt be let into the glaſs as will diſplace the quickſilver, and then, by means of a ſhallow diſh placed below the bell-glaſs, it is to be removed into the common water pneumato-chemical apparatus*, where the air remaining may be examined at large, and with great facility.

When very ſoft and very pure iron has been employed in this experiment, and, when the combuſtion has been performed in the pureſt reſpirable or vital air, free from admixture of the noxious or mephitic part, the air which remains after

* For a particular deſcription of this apparatus, and the manner of uſing it, and of many other proceſſes, with the inſtruments fitted for carrying them on, ſee the third part of this work.——T.

after the combuſtion will be found as pure as it was before: But it is difficult to find iron entirely free from a ſmall portion of charry matter, which is chiefly abundant in ſteel; and it is likewiſe exceedingly difficult to procure pure air perfectly free from ſome admixture of mephitis, with which it is almoſt always contaminated: That ſpecies of noxious air does not, in the ſmalleſt degree, diſturb the reſult of the experiment, as it is always found at the end exactly in the ſame quantity as at the beginning.

I mentioned before, that we have two ways of determining the conſtituent parts of atmoſpheric air, the method of analyſis, and that by ſyntheſis. The calcination of mercury has furniſhed us with an example of each of theſe methods, ſince, after having deprived it of the reſpirable part, by means of the mercury, we have reſtored it again, ſo as to recompoſe an air preciſely ſimilar to that of the atmoſphere. But we can equally accompliſh this ſynthetic compoſition of atmoſpheric air, by borrowing the materials of which it is formed from different kingdoms of nature. We ſhall ſee hereafter that, when animal ſubſtances are diſſolved in the nitric acid, a great quantity of gas is diſengaged, which extinguiſhes light, and is unfit for animal reſpiration, being exactly ſimilar to the noxious or mephitic part of atmoſpheric air.

And,

And, if we take 73 parts, by weight, of this elaſtic fluid, and mix it with 27 parts of highly reſpirable air, procured from calcined mercury, we ſhall form an elaſtic fluid preciſely ſimilar to atmoſpheric air in all its properties.

There are many other methods of ſeparating the reſpirable from the noxious part of the atmoſpheric air, which cannot be taken notice of in this place, without anticipating information, which properly belongs to the ſubſequent chapters. The experiments already adduced may ſuffice for an elementary treatiſe; and, in matters of this nature, the choice of our evidences is of far greater conſequence than their number.

I ſhall cloſe this article, by pointing out the property poſſeſſed by atmoſpheric air, and all the known gaſes, of diſſolving water; which circumſtance it is of great conſequence to attend to in all experiments of this nature. Mr Sauſſure found, by experiment, that a cubical foot of atmoſpheric air is capable of holding 12 grains of water in ſolution *. Other gaſes, as the carbonic acid, appear capable of diſſolving a greater quantity; but experiments are ſtill wanting by

* It is evident that the quantity of water held in ſolution by determinate quantities of the different gaſes, muſt vary according to the degrees of temperature and preſſure.—T.

by which to determine their ſeveral proportions. This water, held in ſolution by gaſes, gives riſe to particular phenomena, which require great attention, in many experiments, and which has frequently proved the ſource of great errors to chemiſts in determining the reſults of their experiments.

CHAP.

CHAP. IV.

Nomenclature of the ſeveral Conſtituent Parts of Atmoſpheric Air.

HITHERTO I have been obliged to make uſe of circumlocution, to expreſs the nature of the ſeveral ſubſtances which conſtitute our atmoſphere, having proviſionally uſed the terms of *reſpirable*, and *noxious*, or *non-reſpirable, parts of the air*. But the inveſtigations I mean to undertake, require a more direct mode of expreſſion; and, having now endeavoured to give ſimple and diſtinct ideas of the different ſubſtances which enter into the compoſition of the atmoſphere, I ſhall henceforth expreſs theſe ideas by words equally ſimple.

The temperature of our earth being very near to that at which water becomes ſolid, and at which reciprocally it changes from ſolid to fluid; and as this phenomenon takes place frequently under our obſervation, it has very naturally followed, that, in the languages of at leaſt every climate ſubject to any degree of winter, a term has been uſed for ſignifying water in the ſtate of ſolidity, or when deprived of its caloric.

loric. The ſame preciſion has not been found neceſſary with reſpect to water reduced to the ſtate of vapour by an additional quantity of caloric. Thoſe perſons who do not make a particular ſtudy of objects of this kind, are ſtill ignorant that water, when in a temperature only a little above the boiling heat, is changed into an elaſtic aëriform fluid, ſuſceptible, like all other gaſes, of being received and contained in veſſels, and of preſerving its gaſeous form ſo long as it remains at the temperature of 212°, and under a preſſure not exceeding 28 inches of the mercurial barometer. As this phenomenon has not been very generally obſerved, no language has uſed a particular term for expreſſing water in this ſtate *; and the ſame thing occurs with all fluids, and all ſubſtances, which do not evaporate in the common temperature, and under the uſual preſſure of our atmoſphere.

For ſimilar reaſons, names have not been given to the liquid or concrete ſtates of moſt of the aëriform fluids: Theſe were not known to ariſe from the combination of caloric with certain baſes; and, as they had not been ſeen either in the liquid or ſolid ſtates, their exiſtence, under theſe forms, was even unknown to natural philoſophers.

We

* In Engliſh, the word *ſteam* is excluſively appropriated to water in the ſtate of vapour—T.

We have not pretended to make any alteration upon ſuch terms as are ſanctified by ancient cuſtom; and, therefore, continue to uſe the words *water* and *ice* in their common acceptation. We likewiſe retain the word *air*, to expreſs that collection of elaſtic fluids which compoſes our atmoſphere: But we have not thought it neceſſary to preſerve the ſame reſpect for modern terms, adopted by the later philoſophers, having conſidered ourſelves as at liberty to reject ſuch as appeared liable to give erroneous ideas of the ſubſtances they are meant to expreſs, and either to ſubſtitute new terms, or to employ the old ones, after having modified them in ſuch a manner as to convey more determinate ideas. New words, when neceſſary, have been borrowed chiefly from the Greek language, in ſuch a manner as to make their etymology convey ſome idea of what was meant to be repreſented by them; and we have always endeavoured to make theſe ſhort, and of ſuch a form as to admit of being changed into adjectives and verbs.

Following theſe principles, we have, after the example of Mr Macquer, retained the term *gas*, employed by Vanhelmont; having arranged the numerous claſs of elaſtic aëriform fluids under that name, excepting only atmoſpheric air. *Gas*, therefore, in our nomenclature, becomes a generic term, expreſſing the fulleſt degree of ſaturation in any body with caloric; being,

ing, in fact, a term expreſſive of a mode of exiſtence. To diſtinguiſh the ſpecies of gas, we employ a ſecond term derived from the name of the baſe, which, ſaturated with caloric, forms each particular gas. Thus, we name water combined to ſaturation with caloric, ſo as to form an elaſtic fluid, *aqueous gas;* ether combined in the ſame manner, *ethereal gas;* the combination of alcohol with caloric, becomes *alcoholic gas;* and, following the ſame principles, we have *muriatic acid gas*, *ammoniacal gas*, and ſo on of every ſubſtance ſuſceptible of being combined with caloric, in ſuch a manner as to aſſume the gaſeous or elaſtic aëriform ſtate.

We have already ſeen, that the atmoſpheric fluid, or common air, is compoſed of two gaſes, or aëriform fluids; one of which is capable, by reſpiration, of contributing to ſupport animal life; and in it metals are calcinable, and combuſtible bodies may burn: The other, on the contrary, is endowed with directly oppoſite qualities; it cannot be breathed * by animals, neither will it admit of the combuſtion of inflammable bodies, nor of the calcination of metals. We have given to the baſe of the former, which is the reſpirable portion of atmoſpheric air, the name

* It may indeed be inſpired into the lungs of animals, but is then ſure to produce inſtant death.—T.

name of *oxygen*, from ὀξυς *acidum*, and γεινομαι *gignor*, becauſe one of the moſt general properties of this baſe is to form acids, by combining with many different ſubſtances. The union of this baſe with caloric, which is the ſame with what was formerly named *pure*, or *vital*, or *highly reſpirable air*, we now call *oxygen gas*. The weight of this gas, at the temperature of 54.50°, and under a preſſure equal to 28 inches of the barometer, is half a grain for each cubical inch nearly, or one ounce and a half to each cubical foot.

The chemical properties of the noxious portion of atmoſpheric air being hitherto but little known, we have been ſatisfied to derive the name of its baſe from its known quality of killing ſuch animals as are forced to breathe it, giving it the name of *azot*, from the Greek privative particle α and ζωη, *vita*; hence the name of the noxious part of the atmoſpheric air is *azotic gas*. The weight of this, in the ſame temperature, and under the ſame preſſure, is 1 *oz.* 2 *drams* and 48 *grs.* to the cubical foot, or 0.4444 of a grain to the cubical inch. We cannot deny, that this name appears ſomewhat extraordinary; but this muſt be the caſe with all new terms, which cannot be expected to become familiar until they have been ſome time in uſe. We long endeavoured to find a more proper deſignation without ſucceſs: It was at

 firſt

firſt propoſed to call it *alkaligen gas*, as, from the experiments of Mr Berthollet, it appears to enter into the compoſition of ammoniac, or volatile alkali; but then, we have as yet no proof of its making one of the conſtituent elements of the other alkalies; beſides, it is proved to form a part of the nitric acid, which gives as good reaſon to have it called *nitrigen*. For theſe reaſons, finding it neceſſary to reject any name upon ſyſtematic principles, we have conſidered that we run no riſk of miſtake, in adopting the terms of *azot*, and *azotic gas*, which only expreſs a matter of fact, or that property which it poſſeſſes, of depriving ſuch animals as breathe it of their lives.

I ſhould anticipate ſubjects more properly reſerved for the ſubſequent chapters, were I in this place to enter upon the nomenclature of the ſeveral ſpecies of gaſes: It is ſufficient, in this part of the work, to eſtabliſh the principles upon which their denominations are founded. The principal merit of the nomenclature we have adopted is, that, when once the ſimple elementary ſubſtance is diſtinguiſhed by an appropriate term, the names of all its compounds derive readily, and neceſſarily, from this firſt denomination.

CHAP.

CHAP. V.

Of the Decompofition of Oxygen Gas by Sulphur, Phofphorous, and Carbon;—and of the Formation of Acids in general.

IN performing experiments, it is a neceffary principle, which ought never to be deviated from, that they be fimplified as much as poffible, and that every circumftance capable of rendering their refults complicated be carefully removed. Wherefore, in the experiments which form the object of this chapter, I have never employed atmofpheric air, which is not a fimple fubftance. It is true, that the azotic gas, which forms a part of its mixture, appears to be merely paffive during combuftion and calcination; but, befides that it retards thefe operations very confiderably, we are not certain but it may even alter their refults in fome circumftances; for which reafon, I have thought it neceffary to remove even this poffible caufe of doubt, by making ufe only of pure oxygen gas in the following experiments, which fhew the effects produced by combuftion in that gas. I fhall advert to fuch differences as take place in the refults of thefe, when the oxygen gas, or pure

vital air, is mixed, in different proportions, with azotic gas.

Having filled a bell-glafs A, Pl. IV. fig. 3. of between five and fix pints meafure, with oxygen gas, I removed it from the water-trough, where it was filled, into the quickfilver bath, by means of a fhallow glafs difh flipped underneath, and having dried the mercury, I introduced $61\frac{1}{4}$ grains of Kunkel's phofphorus in two little China cups, like that reprefented at D, fig. 3., under the glafs A. That I might fet fire to each of the portions of phofphorus feparately, and to prevent the one from catching fire from the other, one of the difhes was covered with a flat piece of glafs. I next raifed the quickfilver in the bell-glafs up to EF, by fucking out a fufficient portion of gas through the fyphon GHI. After this, by means of the crooked iron wire, fig. 16. made red hot, I fet fire to the two portions of phofphorous fucceffively, firft burning that portion which was not covered by the piece of glafs. The combuftion was extremely rapid, being attended by a very brilliant flame, and a confiderable difengagement of light and heat. In confequence of the great heat induced, the gas was at firft much dilated, but foon after the mercury returned to its level, and a confiderable abforption or diminution of gas took place; at the fame time, the whole infide

ſide of the glaſs became covered with light white flakes of concrete phoſphoric acid.

At the beginning of the experiment, the quantity of oxygen gas, reduced, as before directed, to a common ſtandard, of thermometrical temperature and barometrical preſſure, amounted to 162 cubical inches; and, after the combuſtion was finiſhed, only $23\frac{1}{4}$ cubical inches, likewiſe reduced to the ſtandard, remained; ſo that the quantity of oxygen gas abſorbed during the combuſtion was $138\frac{3}{4}$ cubical inches, equal to 69.375 grains.

A part of the phoſphorus remained unconſumed in the bottom of the cups, which, being waſhed on purpoſe to ſeparate the acid, weighed about $16\frac{1}{4}$ grains; ſo that about 45 grains of phoſphorus had been conſumed: But, as it is hardly poſſible to avoid an error of one or two grains, I leave the number ſo far qualified. Hence, as nearly 45 grains of phoſphorus had, in this experiment, united with 69.375 grains of oxygen, and as no gravitating matter could have eſcaped through the glaſs, we have a right to conclude, that the weight of the ſubſtance reſulting from the combuſtion in form of white flakes, muſt equal that of the phoſphorus and oxygen employed, which amounts to 114.375 grains. And we ſhall preſently find, that theſe flakes conſiſted entirely of a ſolid or concrete acid. When we reduce theſe weights to hundredth

dredth parts, it will be found that 100 parts of phoſphorus require 154 parts of oxygen for ſaturation, and that this combination will produce 254 parts of concrete phoſphoric acid, in form of white fleecy flakes.

This experiment proves, in the moſt convincing manner, that, at a certain degree of temperature, oxygen poſſeſſes a ſtronger elective attraction, or affinity, for phoſphorus than for caloric; and that, in conſequence of this, the phoſphorus attracts the baſe of oxygen gas from the caloric, which, being ſet free, ſpreads itſelf over the ſurrounding bodies. But, though this experiment be ſo far perfectly concluſive, it is not ſufficiently rigorous; for, in the apparatus deſcribed above, it is impoſſible to aſcertain the weight of the flakes of concrete acid which are formed; we can therefore only determine this by calculating the weights of oxygen and phoſphorus employed; But as, in phyſics, and in chemiſtry, it is not allowable to ſuppoſe what is capable of being aſcertained by direct experiment, I thought it neceſſary to repeat this experiment, as follows, upon a larger ſcale, and by means of a different apparatus.

I took a large glaſs balloon A, Pl. IV. fig. 4. with an opening of three inches diameter, to which was fitted a cryſtal ſtopper ground with emery, and pierced with two holes for the tubes yyy, xxx. Before ſhutting the balloon with its ſtopper,

ſtopper, I introduced the ſupport BC, ſurmounted by the China cup D, containing 150 *grs.* of phoſphorus; the ſtopper was then fitted to the opening of the balloon, luted with fat lute, and covered with ſlips of linen ſpread with quicklime and white of eggs. When the lute was perfectly dry, the weight of the whole apparatus was determined to within a grain, or a grain and a half. I next exhauſted the balloon, by means of an air-pump applied to the tube xxx, and then introduced oxygen gas by means of the tube yyy, which has a ſtop-cock adapted to it. This kind of experiment is moſt readily and moſt exactly performed by means of the hydro-pneumatic machine deſcribed by Mr Meuſnier and myſelf in the Memoirs of the Academy for 1782, p. 466, and explained in the latter part of this work, with ſeveral important additions and corrections ſince made to it by Mr Meuſnier. With this inſtrument, we can readily aſcertain, in the moſt exact mannner, both the quantity of oxygen gas introduced into the balloon, and the quantity conſumed during the courſe of the experiment.

When all things were properly diſpoſed, I ſet fire to the phoſphorus with a burning glaſs: The combuſtion was extremely rapid, accompanied with a bright flame, and much heat: As the operation went one, large quantities of white flakes gradually attached themſelves to the inner

ner ſurface of the balloon, until at laſt it was rendered quite opake. The quantity of theſe flakes at the end became ſo abundant, that, though freſh oxyen gas was continually ſupplied, which ought to have ſupported the combuſtion, the phoſphorus became extinguiſhed. Having allowed the apparatus to cool completely, I firſt aſcertained the quantity of oxygen gas employed, and weighed the balloon accurately, before it was opened. I next waſhed, dried, and weighed the ſmall quantity of phoſphorus remaining in the cup, on purpoſe to determine the whole quantity of phoſphorus conſumed in the experiment; this reſiduum of the phoſphorus was of a yellow ochrey colour. It is evident, that by theſe ſeveral precautions, I could eaſily determine the weight of the phoſphorus conſumed; the weight of the flakes produced by the combuſtion; and the weight of the oxygen which had combined with the phoſphorus.

This experiment gave very nearly the ſame reſults with the former, as it proved, that the phoſphorus, during its combuſtion, had abſorbed a little more than one and a half its weight of oxygen; and I learned with more certainty, that the weight of the new ſubſtance, produced in the experiment, exactly equalled the ſum of the weights of the phoſphorus conſumed, and oxygen abſorbed, which indeed was eaſily determinable

determinable *à priori*. If the oxygen gas employed be pure, the residuum after combustion is as pure as the gas employed: This proves that nothing escapes from the phosphorus, capable of altering the purity of the oxygen gas, and that the only action of the phosphorus is to separate the oxygen from the caloric, with which it was before united.

I mentioned above, that when any combustible body is burnt in a hollow sphere of ice, or in an apparatus properly constructed upon that principle, the quantity of ice melted during the combustion is an exact measure of the quantity of caloric disengaged. On this subject, the memoir given to the Academy by M. de la Place and myself, *anno* 1780, p. 355, may be consulted. Having submitted the combustion of phosphorus to this trial, we found that one pound of phosphorus melted a little more than 100 pounds of ice during its combustion.

The combustion of phosphorus succeeds equally well in atmospheric air as in oxygen gas, with this difference, that the combustion is vastly slower, being retarded by the large proportion of azotic gas mixed with the oxygen gas; and that only about one-fifth part of the air employed is absorbed, because, as the oxygen gas only is absorbed, the proportion of the azotic gas becomes so great towards the close of the experiment, as to put an end to the combustion.

I have already ſhewn, that phoſphorus is changed by combuſtion into an extremely light, white, flakey matter. Its properties are likewiſe entirely altered by this transformation; from being inſoluble in water, it becomes not only ſoluble, but ſo greedy of moiſture, as to attract the humidity of the air with aſtoniſhing rapidity: By this means it is converted into a liquid, conſiderably more denſe, and of more ſpecific gravity, than water. In the ſtate of phoſphorus before combuſtion, it had ſcarcely any ſenſible taſte; by its union with oxygen it acquires an extremely ſharp and ſour taſte; in a word, from one of the claſs of combuſtible bodies, it is changed into an incombuſtible ſubſtance, and becomes one of thoſe bodies called acids.

This property of a combuſtible ſubſtance to be converted into an acid, by the addition of oxygen, we ſhall preſently find belongs to a great number of bodies: Wherefore, ſtrict logic requires that we ſhould adopt a common term for indicating all theſe operations which produce analogous reſults. This is the true way to ſimplify the ſtudy of ſcience, as it would be quite impoſſible to bear all its ſpecifical details in the memory, if they were not claſſically arranged. For this reaſon, we ſhall diſtinguiſh the converſion of phoſphorus into an acid, by its union with oxygen, and in general every combination of oxygen with a combuſtible ſubſtance,

ſtance, by the term of *oxygenation:* From this I ſhall adopt the verb to *oxygenate ;* and of conſequence ſhall ſay, that in *oxygenating* phoſphorus we convert it into an acid.

Sulphur is likewiſe a combuſtible body, or, in other words, it is a body which poſſeſſes the power of decompoſing oxygen gas, by attracting the oxygen from the caloric with which it was combined. This can very eaſily be proved, by means of experiments quite ſimilar to thoſe we have given with phoſphorus ; but it is neceſſary to premiſe, that in theſe operations with ſulphur, the ſame accuracy of reſult is not to be expected as with phoſphorus ; becauſe the acid which is formed by the combuſtion of ſulphur is difficultly condenſible, and becauſe ſulphur burns with more difficulty, and is ſoluble in the different gaſes. But I can ſafely aſſert, from my own experiments, that ſulphur in burning abſorbs oxygen gas ; that the reſulting acid is conſiderably heavier than the ſulphur burnt ; that its weight is equal to the ſum of the weights of the ſulphur which has been burnt, and of the oxygen abſorbed ; and, laſtly, that this acid is weighty, incombuſtible, and miſcible with water in all proportions. The only uncertainty remaining upon this head, is with regard to the proportions of ſulphur and of oxygen which enter into the compoſition of the acid.

Charcoal,

Charcoal, which, from all our preſent knowledge regarding it, muſt be conſidered as a ſimple combuſtible body *, has likewiſe the property of decompoſing oxygen gas, by abſorbing its baſe from the caloric: But the acid reſulting from this combuſtion does not condenſe in the common temperature; under the preſſure of our atmoſphere, it remains in the ſtate of gas, and requires a large proportion of water to combine with, or be diſſolved in. This acid has, however, all the known properties of other acids though in a weaker degree, and combines, like them, with all the baſes which are ſuſceptible of forming neutral ſalts.

The combuſtion of charcoal in oxygen gas, may be effected like that of phoſphorus in the bell-glaſs, A, Pl. IV. fig. 3. placed over mercury: But, as the heat of red-hot iron is not ſufficient to ſet fire to the charcoal, we muſt add a ſmall morſel of tinder, with a minute particle of phoſphorus, in the ſame manner as is directed in the experiment for the combuſtion of iron. A detailed account of this experiment will be found in the Memoirs of the Academy for

* This aſſertion is to be underſtood of the pure combuſtible part of charcoal, which, in the nomenclature, is named carbon, *carbonum*, to diſtinguiſh it from charcoal, charbon *carbo*: The latter, beſides carbon, contains ſome incombuſtible earth, and certain ſalts.—T.

for 1781, p. 448. By that experiment, it appears, that 28 parts by weight of carbon require 72 parts of oxygen for ſaturation, and that the aëriform acid produced is preciſely equal in weight to the ſum of the weights of the charcoal conſumed and oxygen gas employed during the combuſtion. This aëriform acid was called fixed or fixable air by the chemiſts who firſt diſcovered it; they did not then know whether it was air reſembling that of the atmoſphere, or ſome other elaſtic fluid, vitiated and corrupted by combuſtion; but ſince it is now aſcertained to be an acid, formed like all others by the oxygenation of its peculiar baſe, it is obvious that the name of fixed air is quite ineligible*.

By burning charcoal in the apparatus mentioned, p. 60, Mr de la Place and I found that one *lib.* of charcoal melted 96.375 *libs.* of ice; that, during the combuſtion, 2.5714 *libs.* of oxygen were abſorbed, and that 3.5714 *libs.* of acid gas were formed. This gas weighs 0.695 parts of a grain for each cubical inch, in the common

 ſtandard

* It may be proper to remark, though here omitted by the author, that, in conformity with the general principles of the new nomenclature, this acid is by Mr Lavoiſier and his colleagues called the carbonic acid, and when in the aëriform ſtate, carbonic acid gas.—T.

ſtandard temperature and preſſure mentioned above, ſo that 34242* cubical inches of acid gas are produced by the combuſtion of one pound of charcoal.

I might multiply theſe experiments, and ſhow, by a numerous ſucceſſion of facts, that all acids are formed by the combuſtion of certain ſubſtances; but I am prevented from doing ſo in this place, by the plan which I have laid down, of proceeding only from facts already aſcertained to ſuch as are unknown, and of drawing my examples only from circumſtances already explained. In the mean time, however, the three examples above cited, may ſuffice for giving a clear and accurate conception of the manner in which acids are formed. By theſe, it may be clearly ſeen, that oxygen is an element common to them all, and which conſtitutes or produces their acidity; and that they differ from each other, according to the ſeveral natures of the oxygenated or acidified ſubſtances. We muſt, therefore, in every acid, carefully

* Some error muſt have crept into Mr Lavoiſier's calculation; for, on the data here given, the number of cubical inches of gas ought to have been 47358.3; as 3.5714 *libs.* of carbonic acid gas, or 32914.0224 *grs.* when divided by .695, the weight of a cubical inch, give this corrected quotient.—T.

fully diſtinguiſh between the acidifiable baſe, which Mr de Morveau calls the radical, and the acidifying principle, or oxygen.

CHAP. VI.

Of the Nomenclature of Acids in general, and particularly of thoſe drawn from Nitre and Sea-Salt.

IT becomes extremely eaſy, from the principles laid down in the preceding chapter, to eſtabliſh a ſyſtematic nomenclature for the acids: The word *acid* being uſed as a generic term, each acid falls to be diſtinguiſhed in language, as in nature, by the name of its baſe or radical. Thus, we give the generic name of acids to the products of the combuſtion or oxygenation of phoſphorus, of ſulphur, and of carbon; and theſe products are reſpectively named, the *phoſphoric acid*, the *ſulphuric acid*, and the *carbonic acid*.

There is, however, a remarkable circumſtance in the oxygenation of combuſtible bodies, and of a part of ſuch bodies as are convertible into acids, that they are ſuſceptible o different degrees of ſaturation with oxyger and that the reſulting acids, though formed b the union of the ſame elements, are poſſeſſed c different properties, depending upon that di ference of proportion. Of this, the phoſphori acid, and, more eſpecially, the ſulphuric, fu ni

niſh us with examples. When ſulphur is combined with a ſmall proportion of oxygen, it forms, in this firſt or lower degree of oxygenation, a volatile acid, having a penetrating odour, and poſſeſſed of very peculiar qualities. By a larger proportion of oxygen, it is changed into a fixed, heavy acid, without any odour, and which, by combination with other bodies, gives products quite different from thoſe furniſhed by the former. In this inſtance, the principles of our nomenclature ſeem to fail; and it appears difficult to derive ſuch terms from the name of the acidifiable baſe, as ſhall diſtinctly expreſs theſe two degrees of ſaturation, or oxygenation, without circumlocution. By reflection, however, upon the ſubject, or perhaps rather from the neceſſity of the caſe, we have thought it allowable to expreſs theſe varieties in the oxygenation of the acids, by ſimply varying the termination of their ſpecific names. The volatile acid produced from ſulphur was anciently known to Stahl under the name of *ſulphurous* acid *.

* The term formerly uſed by the Engliſh chemiſts for this acid was written ſulphureous; but I have thought proper to ſpell it as above, that it may better conform with the ſimilar terminations of nitrous, carbonous, &c. to be uſed hereafter. In general, I have uſed the Engliſh terminations *ic* and *ous* to tranſlate the terms of the Author which end with *ique* and *eux*, with hardly any other alterations.—T.

We have preserved that term for this acid from sulphur under saturated with oxygen; and distinguish the other, or completely saturated or oxygenated acid, by the name of *sulphuric* acid. We shall therefore say, in this new chemical language, that sulphur, in combining with oxygin, is susceptible of two degrees of saturation; that the first, or lesser degree, constitutes sulphurous acid, which is volatile and penetrating; while the second, or higher degree of saturation, produces sulphuric acid, which is fixed and inodorous. We shall adopt this difference of termination for all the acids which assume several degrees of saturation. Hence we have a phosphorous and a phosphoric acid, an acetous and an acetic acid; and so on, for others in similar circumstances.

This part of chemical science would have been extremely simple, and the nomenclature of the acids would not have been at all perplexed, as it is now in the old nomenclature, if the base or radical of each acid had been known when the acid itself was discovered. Thus, for instance, phosphorus being a known substance before the discovery of its acid, this latter was rightly distinguished by a term drawn from the name of its acidifiable base. But when, on the contrary, an acid happened to be discovered before its base, or rather, when the acidifiable base from which it was formed remained unknown,

known, names were adopted for the two, which have not the ſmalleſt connection; and thus, not only the memory became burdened with uſeleſs appellations, but the minds of ſtudents, nay even of experienced chemiſts, became filled with falſe ideas, which time and reflection alone are capable of eradicating. We may give an inſtance of this confuſion with reſpect to the acid of ſulphur: The former chemiſts, having procured this acid from the vitriol of iron, gave it the name of the vitriolic acid from the name of the ſubſtance which produced it; and they were then ignorant that the acid procured from ſulphur by combuſtion was exactly the ſame. The ſame thing happened with the aëriform acid, formerly called *fixed air*; it not being known that this acid was the reſult of combining carbon with oxygen, a variety of denominations have been given to it, not one of which conveys juſt ideas of its nature or origin.

We have found it extremely eaſy to correct and modify the ancient language with reſpect to thoſe acids which proceed from known baſes; having converted the name of *vitriolic acid* into that of *ſulphuric*, and the name of *fixed air* into that of *carbonic acid*: But it is impoſſible to follow this plan with the acids whoſe baſes are ſtill unknown; with theſe we have been obliged to uſe a contrary plan, and, inſtead of

forming the name of the acid from that of its base, have been forced to denominate its unknown base from the name of the known acid, as happens in the case of the acid which is procured from sea-salt.

To disengage this acid from the alkaline base with which it is combined, we have only to pour sulphuric acid upon sea-salt; immediately a brisk effervescence takes place, white vapours arise, of a very penetrating odour, and, by gently heating the mixture, all the acid is driven off. As, in the common temperature and pressure of our atmosphere, this acid is naturally in the state of gas, we must use particular precautions for retaining it in proper vessels. For small experiments, the most simple and most commodious apparatus consists of a small retort G, Pl. V. Fig. 5. into which the sea salt is introduced, well dried *; we then pour on some concentrated sulphuric acid, and immediately introduce the beak of the retort under little jars or bell-glasses A, same Plate and Fig. previously filled with quicksilver. In proportion as the acid gas is disengaged, it passes into the jar, and gets to the top of the quicksilver, which it displaces.

* For this purpose, the operation called *decrepitation* is used, which consists in subjecting it to nearly a red heat, in a proper vessel, so as to evaporate all its water of crystallization.—T.

places. When the disengagement of the gas slackens, a gentle heat is applied to the retort, and is gradually increased, till nothing more passes over This acid gas has a very strong affinity with water, which absorbs an enormous quantity of it; this is proved by introducing a very thin layer of water into the glass which contains the gas, for, in an instant, the whole acid gas disappears, and combines with the water.

This latter circumstance is taken advantage of in laboratories and manufactories, on purpose to obtain the acid of sea-salt in a liquid form; and for this purpose the apparatus, Pl. IV. fig. 1., is employed. It consists; of a tubulated retort A, into which the sea-salt, and after it the sulphuric acid, are introduced through the opening H; of the balloon or recipient *c*, *b*, intended for containing the small quantity of liquid which passes over during the process; and of a set of bottles with two mouths, L, L, L, L, half filled with water, intended for absorbing the gas disengaged by the distillation. This apparatus will be more amply described in the latter part of this work.

Although we have not yet been able, either to compose or to decompound this acid of sea-salt, we cannot have the smallest doubt that it, like all other acids, is composed by the union of oxygen with an acidifiable base. We have therefore called this unknown substance the

muriatic

muriatic base, or *muriatic radical*, deriving this name, after the example of Mr Bergman and Mr de Morveau, from the Latin word *muria*, which was anciently used to signify sea-salt. Thus, without being able exactly to determine the component parts of *muriatic acid*, we design by that term a volatile acid, which retains the form of gas in the common temperature and pressure of our atmosphere; which combines with great facility, and in great quantity, with water; and whose acidifiable base adheres so very intimately with oxygen, that no method has hitherto * been devised for separating them. If ever this acidifiable base of the muriatic acid is discovered to be a known substance, though now unknown in that capacity, it will be requisite to change its present denomination for one analogous with that of its base.

In

* Dr Girtanner is said to have lately discovered, that Hydrogen is the base or radical of this acid. Should this discovery be confirmed, the terms will here require some farther alteration, in conformity with the general principles of the new nomenclature. At any rate, *muriogen* may be employed to denominate the base of the muriatic acid, till its nature be unequivocally determined; and, if the discovery attributed to Dr Girtanner be ascertained, the common base of water and muriatic acid will more properly fall to be named by this new term, than by that of Hydrogen.—T.

In common with ſulphuric acid, and ſeveral other acids, the muriatic is capable of different degrees of oxygenation; but the exceſs of oxygen produces quite contrary effects upon it from what the ſame circumſtance produces upon the acid of ſulphur. The lower degree of oxygenation converts ſulphur into a volatile gaſeous acid, which only mixes in ſmall proportions with water; while a higher oxygenation forms an acid poſſeſſing much ſtronger acid properties, which is very fixed, and cannot remain in the ſtate of gas, but in a very high temperature, which has no ſmell, and which mixes in large proportion with water. With muriatic acid, the direct reverſe takes place; an additional ſaturation with oxygen renders it more volatile, of a more penetrating odour, leſs miſcible with water, and diminiſhes its acid properties. We were at firſt inclined to have denominated theſe two degrees of ſaturation in the ſame manner as we had done with the acid of ſulphur, calling the leſs oxygenated *muriatous acid*, and that which is more ſaturated with oxygen *muriatic acid*: But, as this latter gives very particular reſults in its combinations, and as nothing analogous to it is yet known in chemiſtry, we have left the name of muriatic acid to the leſs ſaturated, and give the latter the

more

more compounded appellation of *oxygenated muriatic acid* *.

Although the baſe or radical of the acid which is extracted from nitre or ſaltpetre be better known, we have judged proper only to modify its name in the ſame manner with that of the muriatic acid. It is procured from nitre, by the intervention of ſulphuric acid, by a proceſs ſimilar to that deſcribed for extracting the muriatic acid, and by means of the ſame apparatus, Pl. IV. Fig. 1. In proportion as the acid paſſes over, it is in part condenſed in the balloon or recipient, and the reſt is abſorbed by the water contained in the bottles L, L, L, L; the water becomes firſt green, then blue, and at laſt yellow, in proportion to the concentration of the acid. During this operation, a large quantity of oxygen gas, mixed with a ſmall proportion of azotic gas, is diſengaged.

This acid, like all others, is compoſed of oxygen, united to an acidifiable baſe, and is even the firſt acid in which the exiſtence of oxygen was

* The compound term, *murioxic acid*, might ſerve very conveniently for expreſſing this ſtate of the muriatic acid: In ſtrict conformity with the general principles of the new chemical philoſophy, and its nomenclature, it ſhould have been called *ſuper-oxygenated*, inſtead of oxygenated muriatic acid; for all acids are oxygenated.—T.

was well ascertained. Its two constituent elements are but weakly united, and are easily separated, by presenting any substance with which oxygen has a stronger affinity than with the acidifiable base peculiar to this acid. By some experiments of this kind, it was first discovered that azot, or the base of mephitis or of azotic gas, constituted its acidifiable base or radical; and consequently, that the acid of nitre was really an azotic acid, having azot for its base, combined with oxygen. For these reasons, that we might be consistent with our principles, it appeared necessary, either to call the acid *azotic*, or to name the base *nitric radical;* but from either of these we were dissuaded, by the following considerations. It seemed difficult to change the name of nitre or saltpetre, which have been universally adopted in society, in manufactures, and in chemistry; and, on the other hand, azot having been discovered by Mr Berthollet to be the base of volatile alkali, or ammoniac, as well as of this acid, we thought it improper to call it nitric radical. We have therefore continued the term of azot to the base of that part of atmospheric air which is likewise the nitric and ammoniacal radical; and we have named the acid of nitre, in its lower and higher degrees of oxygenation, *nitrous acid* in the former,

mer, and *nitric acid* in the latter ſtate; thus preſerving its former appellation properly modified.

Several very reſpectable chemiſts have diſapproved of this deference for the old terms, and wiſhed us to have perſevered in perfecting a new chemical language, without paying any reſpect to ancient uſage; ſo that, by thus ſteering a ſort of middle courſe, we have expoſed ourſelves to the cenſures of one ſect of chemiſts, and to the expoſtulations of the oppoſite party.

The acid of nitre is ſuſceptible of aſſuming a great number of ſeparate ſtates, depending upon its degree of oxygenation, or upon the proportions in which azot and oxygen enter into its compoſition. By a firſt or loweſt degree of oxygenation, it forms a particular ſpecies of gas, which we ſhall continue to name *nitrous gas*; this is compoſed nearly of two parts, by weight, of oxygen combined with one part of azot, and in this ſtate it is not miſcible with water. In this gas, the azot is by no means fully ſaturated with oxygen, but, on the contrary, has ſtill a very great affinity for that element, and even attracts it from atmoſpheric air, immedately upon getting into contact with it. This combination of nitrous gas with the oxygen gas contained in atmoſpheric air, has even become

one

one of the methods for determining the quantity of oxygen gas mixed with any portion of air, and consequently is used as a test for ascertaining its degree of salubrity.

The further addition of oxygen converts the nitrous gas into a powerful acid, which has a strong affinity with water, and which is itself susceptible of various additional degrees of oxygenation. When the proportions of oxygen and azot are below three parts, by weight, of the former to one of the latter, the acid is red coloured, and emits copious fumes. In this state, by the application of a gentle heat, it gives out nitrous gas; and we term it, in this degree of oxygenation, *nitrous acid*. When four parts, by weight, of oxygen, are combined with one part of azot, the acid is clear and colourless; more fixed in the fire than the nitrous acid; has less odour, and its constituent elements are more firmly united: This species of acid, in conformity with our principles of nomenclature, is called *nitric acid*.

Thus, nitric acid is the acid of nitre, surcharged with oxygen; nitrous acid is the acid of nitre surcharged with azot, or what is the same thing, with nitrous gas; and this latter is azot not sufficiently saturated with oxygen to possess the properties of an acid. To this lat-

ter

ter degree of oxygenation, we have afterwards, in the courſe of this work, given the generical name of *oxyd* *.

CHAP.

* In ſtrict conformity with the principles of the new nomenclature, but which the author has given his reaſons for deviating from in this inſtance, the following ought to have been the terms for azot, in its ſeveral degrees of oxygenation: Azot, azotic gas (azot combined with caloric), azotic oxyd gas, azotous acid, and azotic acid.—T.

CHAP. VII.

Of the Decompoſition of Oxygen Gas by means of Metals, and the Formation of Metallic Oxyds.

OXYGEN has a ſtronger affinity with metals that are heated to a certain degree than with caloric: In conſequence of this, all metallic bodies, excepting gold, ſilver, and platina, have the property of decompoſing oxygen gas, by attracting its baſe from the caloric with which it was combined. We have already ſhown in what manner this decompoſition is effected by means of mercury and iron; having obſerved, that, in the caſe of the firſt, it muſt be conſidered as a kind of gradual combuſtion, whereas, in the latter, the combuſtion is extremely rapid, and is attended with a brilliant flame. The uſe of the heat employed in theſe operations is to ſeparate the particles of the metal from each other, and to diminiſh their attraction of coheſion or aggregation, or, what is the ſame thing, their mutual attraction for each other.

The abſolute weight of all metallic ſubſtances is augmented in proportion to the quantity

of oxygen they abſorb ; they, at the ſame time, loſe their metallic ſplendour, and are reduced to the appearance of an earthy pulverulent matter : In this ſtate, metals muſt not be conſidered as entirely ſaturated with oxygen, becauſe their action upon this element is counter-balanced by the power of affinity between it and the caloric. During the calcination of metals, the oxygen is therefore acted upon by two ſeparate and oppoſite powers, that of its attraction for caloric, and that exerted by the metal; and it only tends to unite with the metal in conſequence of the exceſs of the latter power over the former, which is, in general, very inconſiderable. Wherefore, when metallic ſubſtances are oxygenated in atmoſpheric air, or in oxygen gas, they are not converted into acids, like ſulphur, phoſphorus, and carbon, but are only changed into intermediate ſubſtances, which, though approaching to the nature of ſalts, have not acquired all the ſaline properties.

The older chemiſts have affixed the name of *calx* not only to metals in this ſtate, but to every body which has been long expoſed to the action of fire without being melted. They have employed this word *calx* as a generical term ; under which they confound calcareous earth, which, from a neutral ſalt, which it really was before calcination, has been changed

ged by fire into an earthy alkali, by *loſing* half of its weight; and metals, which, by the ſame means, have joined themſelves to a new ſubſtance, the added quantity of which often *exceeds* half their weight, and by the addition of which they have been changed almoſt into the nature of acids. This mode of claſſifying ſubſtances, of ſo very oppoſite natures, under the ſame generic name, would have been quite contrary to our principles of nomenclature; eſpecially as, by retaining the above term for this ſtate of metallic ſubſtances, we muſt have conveyed very falſe ideas of its nature. We have, therefore, laid aſide the expreſſion *metallic calx* altogether, and have ſubſtituted in its place the term *oxyd*, from the Greek word ὀξυς.

By this readineſs for ſupplying appoſite terms, it is evident that the language we have adopted is both copious and expreſſive. The firſt or loweſt degree of oxygenation in bodies, converts them into *oxyds*; a ſecond degree of additional oxygenation conſtitutes that claſs of acids, of which the ſpecific names, drawn from their particular baſes, terminate in *ous*, as the *nitrous* and *ſulphurous* acids; the third degree of oxygenation changes theſe into that diviſion of acids, which are diſtinguiſhed by the termination in *ic*, as the *nitric* and *ſulphuric* acids; and, laſtly, we can expreſs a fourth, or higheſt degree of oxygenation, by adding the word *oxy-*

genated to the name of the acid, as has been already done with the *oxygenated muriatic* acid.

We have not confined the term *oxyd* to the purpose of expressing the combination of metals with oxygen, but have extended it to signify that first degree of oxygenation in all bodies, which, without converting them into acids, causes them to approach to the nature of salts. Thus, we give the name of *oxyd of sulphur* to that soft substance into which sulphur is converted by incipient, or imperfect combustion; and we call the yellow matter left by phosphorus, after combustion, by the name of *oxyd of phosphorus.* In the same manner, nitrous gas, which is azot in its first degree of oxygenation, is the *oxyd of azot* *. We have likewise oxyds in great numbers from the vegetable and animal kingdoms; and I shall shew, in the sequel, that this new language throws great light upon all the operations of art and nature.

We have already observed, that almost all the metallic oxyds have peculiar and permanent

* Mr Lavoisier here uses the term oxyd of azot, but it is no where else adopted in the new nomenclature; though as I have mentioned in a former note, it is more legitimate than the term nitrous gas; which last he has retained, both because it has long been employed, and chiefly because, as a familiar term in chemistry, it conveys no ideas contradictory to the real nature of the substance it is meant to express.—T.

nent colours. Thefe vary not only in the different fpecies of metals, but even according to the various degrees of oxygenation in the fame metal. Hence we are under the neceffity of adding two epithets to each oxyd, one of which indicates the metal *oxydated* *, while the other indicates the peculiar colour of the oxyd. Thus, we have the black oxyd of iron, the red oxyd of iron, and the yellow oxyd of iron; which expreffions refpectively anfwer to the old unmeaning terms of martial ethiops, colcothar, and ruft of iron, or ochre. We have likewife the grey, yellow, and red oxyds of lead, which anfwer to the equally falfe or infignificant old terms, litharge, afhes of lead, mafficot, and minium.

Thefe denominations fometimes become rather long, efpecially when we mean to indicate whether the metal has been oxydated in the air, by detonation with nitre, or by means of acids; but then they always convey juft

* Here we fee the word *oxyd* converted into the verb *to oxydate, oxydated, oxydating*, after the fame manner, with the derivation of the verb *to oxygenate, oxygenated, oxygenating*, from the word *oxygen*. I am not clear of the abfolute neceffity of this fecond verb here firft introduced, but think, that, in a work of this nature, it is the duty of the tranflator to neglect every other confideration for the fake of ftrict fidelity to the ideas of his author.—T.

and accurate ideas of the correſponding objects which we wiſh to expreſs by their uſe. All this will be rendered perfectly clear and diſtinct by means of the tables which are added to this work.

CHAP. VIII.

Of the Radical Principle of Water, and of its Decompoſition by Charcoal and Iron.

UNTIL very lately, water has always been thought a ſimple ſubſtance; inſomuch that the older chemiſts conſidered it as an element. Such it undoubtedly was to them, as they were unable to decompoſe it; or, at leaſt, ſince the decompoſition which took place daily before their eyes, was entirely unnoticed. But we mean to prove, that water is by no means a ſimple or elementary ſubſtance. I ſhall not here pretend to give the hiſtory of this recent, and hitherto conteſted diſcovery, which is detailed in the Memoirs of the Academy for 1781, but ſhall only bring forward the principal proofs of the decompoſition, and compoſition of water; and I may venture to ſay, that theſe will be convincing to ſuch as conſider them impartially.

Experiment Firſt.

Having fixed the glaſs tube EF, Plate VII. Fig. 11. of from 8 to 12 lines diameter, acroſs a

furnace, with a ſmall inclination from E to F; lute the ſuperior extremity E to the glaſs retort A, containing a determinate quantity of diſtilled water; and to the ſuperior extremity F, lute the worm SS, fixed into the neck of the doubly tubulated bottle H; which laſt has the bent tube KK adapted to one of its openings, in ſuch a manner as to convey ſuch aëriform fluids or gaſes as may be diſengaged during the experiment, into a proper apparatus for determining their quantity and nature.

To render the ſucceſs of this experiment certain, it is neceſſary that the tube EF be made of well annealed and difficultly fuſible glaſs, and that it be coated over with a lute compoſed of clay mixed with powdered ſtone-ware; beſides which, it muſt be ſupported about its middle by means of an iron bar paſſed through the furnace, leſt it ſhould ſoften and bend during the experiment. A tube of China-ware or porcelain, would anſwer better than one of glaſs for this experiment, were it not difficult to procure one ſo entirely free from pores as to prevent the paſſage of the air or vapours.

When things are thus arranged, a fire is lighted in the furnace EFCD, which is ſupported of ſuch a ſtrength as to keep the tube EF red hot, but not to make it melt; and, at the ſame time, ſuch a fire is kept up in the furnace VVXX, as

to keep the water in the retort A continually boiling.

In proportion as the water, in the retort A, is evaporated, it fills the tube EF, and drives out the air contained through the tube KK; the aqueous gas formed by evaporation is condenfed by cooling in the worm SS, and falls, drop by drop, into the tubulated bottle H. Having continued this operation until all the water be evaporated from the retort, and having carefully emptied all the veffels employed, we find that a quantity of water has paffed over into the bottle H, exactly equal to what was before contained in the retort A, without any difengagement of gas whatfoever: So that this experiment turns out to be a fimple diftillation; and the refult would have been exactly the fame, if the water had been run from one veffel into the other, without having undergone the intermediate incandefcence, by paffing through the red-hot tube EF.

Experiment Second.

The apparatus being difpofed, as in the former experiment; 28 *grs.* of charcoal, broken into moderately fmall parts, and which has previoufly been expofed for a long time to a red heat in clofe veffels, are introduced into the tube

EF: Every thing elſe is managed exactly as in the preceding experiment.

The water, contained in the retort A, is diſtilled, as in the former experiment, and, being condenſed in the worm SS, falls into the bottle H; but, at the ſame time, a conſiderable quantity of gas is diſengaged, which, eſcaping by the tube KK, is received in a convenient apparatus for that purpoſe. After the operation is finiſhed, we find nothing but a few atoms of aſhes remaining in the tube EF; the 28 *grs.* of charcoal having entirely diſappeared.

When the diſengaged gaſes are carefully examined, they are found to weigh 113.7 *grs.**; theſe are of two kinds, viz. 144 cubical inches of carbonic acid gas, weighing 100 *grs.* and 380 cubical inches of a very light gas, weighing only 13.7 *grs.*; this latter gas takes fire, when in contact with air, by the approach of a lighted body; and when the water which has paſſed over into the bottle H is carefully examined, it is found to have loſt 85.7 *grs.* of its weight. Hence, in this experiment, 85.7 *grs.* of water, joined to 28 *grs.* of charcoal, have combined in ſuch a way as to form 100 *grs.* of carbonic acid,

* In the latter part of this work, will be found a particular account of the proceſſes neceſſary for ſeparating the different kinds of gaſes, and for determining their quantities, and the particular natures of each.—T.

acid, and 13.7 *grs.* of a particular gas capable of being burnt.

I have already ſhown, that 100 *grs.* of carbonic acid gas conſiſt of 72 *grs.* of oxygen, combined with 28 *grs.* of carbon; hence the 28 *grs.* of charcoal placed in the glaſs tube have acquired 72 *grs.* of oxgyen from the water; and it follows, that 85.7 *grs.* of water are compoſed of 72 *grs.* of oxygen, combined with 13.7 *grs.* of a gas ſuſceptible of combuſtion. We ſhall ſee preſently that this gas cannot poſſibly have been diſengaged from the charcoal, and muſt conſequently have been produced from the water.

I have ſuppreſſed ſome circumſtances in the above account of this experiment, which would only have rendered it complicated, and made its reſults obſcure to the reader. For inſtance, the inflammable gas diſſolves a very ſmall part of the carbon, by which means its own weight is ſomewhat augmented, and that of the carbonic gas is proportionally diminiſhed. Although the alteration produced by this circumſtance is very inconſiderable, yet I have thought it neceſſary to determine its effects by a rigid calculation, and to report, as above, the reſults of the experiment in its ſimplified ſtate, as if the circumſtance had not happened. At any rate, ſhould any doubts remain reſpecting the conſequences I have drawn from this experiment,

ment, they will be fully diſſipated by the following experiments, which I am going to adduce in ſupport of my opinion.

Experiment Third.

The apparatus being diſpoſed exactly as in the former experiment, with this difference, that inſtead of the 28 *grs.* of charcoal, the tube EF is filled with 274 *grs.* of ſoft iron, in thin plates, rolled up ſpirally; the tube is made red-hot by means of its furnace, and the water, in the retort A, is kept conſtantly boiling till it be all evaporated, and has paſſed through the tube E F, to be condenſed in the bottle H.

No carbonic acid is diſengaged in this experiment; inſtead of which we obtain 416 cubical inches, or 15 *grs.* of inflammable gas, thirteen times lighter * than atmoſpheric air. By examining the water which has been diſtilled, it is found to have loſt 100 *grs.* and the 274 *grs.* of iron confined in the tube are found to

* This I conceive to be a very improper expreſſion. I underſtand the meaning of one ſubſtance being thirteen times heavier than another, but I do not underſtand how one can be thirteen times lighter. One-thirteenth of the weight of the heavier would be the proper expreſſion for implying the comparative gravity of the lighter body.—T.

to have acquired 85 *grs.* additional weight, and its magnitude is conſiderably augmented. The iron is now hardly attractable by the magnet; it diſſolves in acids without effervеſcence; in ſhort, it is converted into a black oxyd, preciſely ſimilar to that produced by the combuſtion of iron in oxygen gas.

In this experiment we have a true *oxydation* of iron by means of water, exactly ſimilar to that produced in air by the aſſiſtance of heat. One hundred grains of water having been decompoſed, 85 *grs.* of oxygen have combined with the iron, ſo as to convert it into the ſtate of black oxyd, and 15 *grs.* of a peculiar inflammable gas are diſengaged: From all this it clearly follows, that water is compoſed of oxygen combined with the baſe of an inflammable gas, in the reſpective proportion of 85 parts by weight of the former, to 15 parts of the latter.

Thus water, beſides the oxygen, which is one of its elements, as it is of many other ſubſtances, contains another element as its conſtituent baſe or radical, and for this proper principle or element we muſt find an appropriate term. None that we could think of ſeemed better adapted than the word *hydrogen*, which ſignifies the *generative principle of water*, from ὑδωρ *aqua*, and γειvομαι *gig-*

nor *. We call the combination of this element with caloric *hydrogen gas ;* and the term hydrogen † expreſſes the baſe of that gas, or the radical of water.

This experiment furniſhes us with a new combuſtible body, or, in other words, a body which has ſo much affinity with oxygen as to draw it from its connection with caloric, and to decompoſe oxygen gas. This combuſtible body has itſelf ſo great an affinity with caloric, that, unleſs when engaged in a combination with ſome other body, it always ſubſiſts in the aëriform or gaſeous ſtate, in the uſual temperature and preſſure of our atmoſphere. In this ſtate of gas it is about $\frac{1}{13}$ of the weight of an equal bulk of atmoſpheric

* This expreſſion Hydrogen, has been very ſeverely criticiſed by ſome, who pretend that it ſignifies engendered by water, and not that which engenders water. I am not Grecian enough to ſettle the grammatical diſpute, but the experiments related in this chapter prove, that, when water is decompoſed, hydrogen is produced, and that, when hydrogen is combined with oxygen, water is produced ; hence we may ſay, with equal truth, that water is produced from hydrogen, or hydrogen is produced from water.—T.

† In a former note, it is mentioned that this element appears to be the baſe of muriatic acid, and that, if the diſcovery be authentic, it might more properly be named *muriogen ;* in this caſe what the older chemiſts named inflammable air, will become, in the new nomenclature, *muriogen gas*, and water will become a real *oxyd of muriogen.*—T.

atmoſpheric air; it is not abſorbed by water, though it is capable of holding a ſmall quantity of that fluid in ſolution; and it is incapable of being uſed for reſpiration, without producing inſtant death.

As the property of burning, which this gas poſſeſſes in common with all other combuſtible bodies, is merely the power of decompoſing air, and carrying off its oxygen from the caloric with which it is combined, it is eaſily underſtood that it cannot burn, unleſs in contact with air or oxygen gas. Hence, when we ſet fire to a bottle full of this gas, it burns gently, firſt at the neck of the bottle, and then in the inſide of it, in proportion as the external air gets in: This combuſtion is ſlow and ſucceſſive, and only takes place at the ſurface of contact between the two gaſes. It is quite different when the two gaſes are mixed before they are ſet on fire; If, for inſtance, after having introduced one part of oxygen gas into a narrow-mouthed bottle, we fill it up with two parts of hydrogen gas, and bring a lighted taper, or other burning body, to the mouth of the bottle, the combuſtion of the two gaſes takes place inſtantaneouſly with a violent exploſion. This experiment ought only to be made in a bottle of very ſtrong green glaſs, holding not more than a pint, and ſtrongly wrapped round with twine, otherwiſe the operator will be expoſed to great

danger

danger from the rupture of the bottle, of which the fragments will be thrown about with great force.

If all that has been related above, concerning the decompoſition of water, be exactly conformable to truth;—if, as I have endeavoured to prove, that ſubſtance be really compoſed of hydrogen, as its proper conſtituent element, combined with oxygen, it ought to follow, that by reuniting theſe two elements together, we ſhould recompoſe water; and that this actually happens, may be judged off by the following experiment.

Experiment Fourth.

I took a large cryſtal balloon, A, Pl. IV. Fig. 5. holding about 30 pints, having a large opening, to which was cemented the plate of copper B C, pierced with four holes, in which four tubes terminate. The firſt tube, H h, is intended to be adapted to an air-pump, by which the balloon may be exhauſted of its air. The ſecond tube gg, communicates, by its extremity MM, with a reſervoir of oxygen gas, from which the ballon is to be filled. The third tube d D d', communicates, by its extremity dNN, with a reſervoir of hydrogen gas. The extremity d' of this tube terminates in a capillary

pillary opening, through which the hydrogen gas contained in the reſervoir, is forced, with a moderate degree of quickneſs, by the preſſure of one or two inches of water. The fourth tube contains a metallic wire GL, having a knob at its extremity L, intended for giving an electrical ſpark from L to d', on purpoſe to ſet fire to the hydrogen gas: This wire is moveable in the tube, that we may be able to ſeparate the knob L from the extremity d' of the tube D d'. The three tubes d D d' gg, and Hh, are all provided with ſtop-cocks.

That the hydrogen gas and oxygen gas may be as much as poſſible deprived of water, they are made to paſs, in their way to the balloon A, through the tubes MM, NN, of about an inch diameter, and theſe are filled with ſalts, which, from their deliqueſcent nature, greedily attract the moiſture of the air: Such are the acetite of potaſh, and the muriat or nitrat of lime*. Theſe ſalts muſt only be reduced to a coarſe powder, leſt they run into lumps, and prevent the gaſes from getting through their interſtices.

We muſt be provided before-hand with a ſufficient quantity of oxygen gas, carefully pu-

 rified

* See the nature of theſe ſalts in the ſecond part of this book.—A.

rified from all admixture of carbonic acid, by long contact with a solution of potash *.

We must likewise have a quantity of hydrogen gas, equal to twice the bulk of the oxygen gas, and contained in a separate reservoir: this must be carefully purified in the same manner by long contact with a solution of potash in water. The best way to obtain this gas free from mixture is, by decomposing water with pure soft iron, as directed in Exp. 3. of this chapter.

Having adjusted every thing properly, as above directed, the tube H h is adapted to an air-pump, and the balloon A is exhausted of its air. We next admit the oxygen gas, so as to fill the balloon; and then, by means of pressure, as is before mentioned, force a small stream of hydrogen gas, through its tube D d', to which we immediately set fire by an electrical spark. By means of the above-described apparatus, we can continue the mutual combustion of these two gases for a long time; as we have the power of supplying them, to the balloon, from their reservoirs, in proportion as they are consumed.

* By potash is here meant, pure or caustic vegetable alkali, deprived of carbonic acid by means of quick-lime. In general, we may observe here, that all the alkalies and earths must invariably be considered as in their pure or caustic state, unless otherwise expressed.—T. The method of obtaining this pure alkali of potash will be given in the sequel.—A.

ſumed. I have in another place * given a minute deſcription of the apparatus uſed in this experiment, and have explained the manner of aſcertaining the quantities of the gaſes conſumed with the moſt ſcrupulous exactitude.

In proportion to the advancement of the combuſtion, there is a depoſition of water upon the inner ſurface of the balloon or matraſs A: The water gradually increaſes in quantity, and, gathering into large drops, runs down to the bottom of the veſſel. It is eaſy to aſcertain the quantity of water collected, by weighing the balloon both before and after the experiment. Thus we have a twofold verification of our experiment, by aſcertaining both the quantities of the gaſes employed, and of the water formed by their combuſtion: Theſe two quantities muſt be equal to each other. By an operation of this kind, Mr Meuſnier and I aſcertained that it required 85 parts by weight, of oxygen, united to 15 parts of hydrogen, to compoſe one hundred parts of water. This experiment, which has not hitherto been publiſhed, was made in preſence of a numerous committee from the Academy of Sciences. We exerted, on that occaſion, the moſt ſcrupulous attention to accuracy; and have reaſon to be-

 lieve

* See the third part of this work.—A.

lieve that the above proportions cannot vary a two hundredth part from abſolute truth.

From theſe experiments, both analytical and ſynthetic, we may now affirm, that we have aſcertained with as much certainty as is poſſible in phyſical or chemical ſubjects, that water is not a ſimple elementary ſubſtance, but is compoſed of two elements, oxygen and hydrogen; which elements, when exiſting ſeparately, have ſo ſtrong an affinity for caloric, as only to ſubſiſt under the form of gas in the common temperature and preſſure of our atmoſphere.

This decompoſition and recompoſition of water is perpetually operating before our eyes, in the temperature of the atmoſphere, by means of compound elective attractions. We ſhall preſently ſee that the phenomena attendant upon vinous fermentation, putrefaction, and even vegetation, are produced, at leaſt in a certain degree, by the decompoſition of water. It is very extraordinary that this fact ſhould have hitherto been overlooked by natural philoſophers and chemiſts. Indeed, it ſtrongly proves, that, in chemiſtry, as in natural philoſophy, it is extremely difficult to overcome prejudices imbibed in early education, and to ſearch for truth in any other road than the one we have been accuſtomed to follow.

I ſhall finiſh this chapter with an account of an experiment, much leſs demonſtrative indeed than

than thofe already related, but which has appeared to make more impreffion than any other upon the minds of many. When 16 ounces of alcohol are burnt in an apparatus * properly adapted for collecting all the water difengaged during the combuftion, we obtain from 17 to 18 ounces of water. As no fubftance can furnifh a product larger than its original bulk, it is evident that fomething muft have united with the alcohol during its combuftion; and I have already fhewn that this muft be oxygen. Thus alcohol contains hydrogen, which is one of the elements of water; and the atmofpheric air contains oxygen, which is the other element neceffary to the compofition of water †. This experiment is a new proof that water is a compound fubftance.

 CHAP.

* See an account of this apparatus in the third part of this work.—A.

† A large quantity of carbonic acid gas is likewife difengaged during the combuftion of alcohol: this proceeds from the combination of carbon, contained along with hydrogen in the compofition of the alcohol, with oxygen during the combuftion. This latter circumftance is explained at large in the after parts of this work.—T.

CHAP. IX.

Of the Quantities of Caloric disengaged during different Species of Combustion.

IT has been already mentioned, that when equal quantities of different bodies are burnt in the centre of a hollow sphere of ice, and are supplied with air at the temperature of 32°, the quantities of ice melted from the inside of the sphere, become measures of the relative quantities of caloric disengaged during the several combustions. Mr de la Place and I have given a description of the apparatus employed for this kind of experiment, in the Memoirs of the Academy for 1780, p. 355; and a description and plate of the same apparatus will be found in the third part of this work. With this apparatus, phosphorus, charcoal, and hydrogen gas, gave the following results.

One pound of phosporus melted 100 *libs.* * of ice.

One

* In the original, the quantities resulting from the several experiments mentioned in this Chapter, are given in pounds, ounces, gros, and grains; but as the subject is curious and interesting, they are here reduced to decimals of the pound, by which they become equally useful to the British as to the French reader.—T.

One pound of charcoal melted 96.5 *libs.*

One pound of hydrogen gas melted 295.5895 *libs.*

As a concrete acid is formed by the combuſtion of phoſphorus, it is probable that very little caloric remains in the acid; and, conſequently, that the above experiment gives us very nearly the whole quantity of caloric contained in the oxygen gas. Even if we ſuppoſe the phoſphoric acid to contain a good deal of caloric, yet, as the phoſphorus muſt have contained nearly an equal quantity before combuſtion, the error muſt be very ſmall, as it will only conſiſt of the difference between what was contained in the phoſphorus before, and in the phoſphoric acid after combuſtion.

I have already ſhown, in Chap. V. that one pound of phoſphorus abſorbs one pound eight ounces of oxygen during combuſtion; and, ſince by the ſame operation, 100 *libs.* of ice are melted, it follows, that the quantity of caloric contained in one pound of oxygen gas is capable of melting 66.6667 *libs.* of ice.

One pound of charcoal during combuſtion melts only 96.5 *libs.* of ice, while it abſorbs 2.5714 *libs.* of oxygen. By the experiment with phoſphorus, this quantity of oxygen gas ought to diſengage a quantity of caloric ſufficient to melt 171.414 *libs.* of ice; conſequently, during this experiment, a quantity of coloric

fufficient to melt 74.914 *libs.* of ice difappears. Carbonic acid is not, like phofphoric acid, in a concrete ftate, after combuftion, but in the ftate of gas, and requires to be united with caloric to enable it to fubfift in that ftate; and the quanty of caloric which is miffing in the laft experiment is evidently employed for that purpofe. When we divide that quantity by the weight of carbonic acid, formed by the combuftion of one pound of charcoal, we find that the quantity of caloric, neceffary for changing one pound of carbonic acid from the concrete to the gafeous ftate, would be capable of melting 20.9766 *libs.* of ice.

We may make a fimilar calculation with the combuftion of hydrogen gas and the confequent formation of water: During the combuftion of one pound of hydrogen gas, 5.6667 *libs.* of oxygen gas are abforbed, and 295.5895 *libs.* of ice are melted. But 5.6667 *libs.* of oxygen gas, in changing from the aëriform to the folid ftate, lofe, according to the experiment with phofphorus, enough of caloric to have melted 377.7534 *libs.* of ice. There is only difengaged, from the fame quantity of oxygen, during its combuftion with hydrogen gas, as much caloric as melts 295.1523 *libs.*; wherefore there remains in the water at 32°, which is formed during this experiment, as much caloric as would melt 82.6211 *libs.* of ice.

Hence,

Hence, as 6.6667 *libs.* of water are formed, from the combuftion of one pound of hydrogen gas, with 5.6667 *libs.* of oxygen; it follows, that in each pound of water, at the temperature of 32°, there exifts as much caloric as would melt 12.2708 *libs.* of ice; without taking into account the quantity originally contained in the hydrogen gas, which we have been obliged to omit, for want of data to calculate its quantity *. From this it appears, that water, even in the ftate of ice, contains a confiderable

* From the general principles of the new chemical philofophy, hydrogen gas ought to contain a much larger quantity of caloric for giving it the gafeous ftate than oxygen gas. Being thirteen times as rare, it may be fuppofed to contain thirteen times as much caloric. Hence, if all the caloric of the two gafes were difengaged during their combuftion, and the confequent formation of water, 1244.4167 *libs.* of ice fhould have been melted; but only 295.1522 *libs.* are melted; and therefore, on this fuppofition, the remaining caloric in 6.6667 *libs.* of water would be able to melt 94.92643 *libs.* of ice; or each pound of water at the temperature of 32°, fhould contain as much caloric as is fufficient to melt 142 *libs.* of ice nearly, which is abfurd; for one pound of water, at 32°, muft contain precifely as much caloric as is neceffary to melt one pound of ice. This fhews the fallacy of all reafonings drawn from the fuppofable quantities of caloric in bodies; and that we are hitherto very far from poffeffing any accurate knowledge of that part of chemiftry in which caloric is concerned.—T.

able quantity of caloric, and that oxygen, in entering into the combination, retains likewiſe a good proportion.

From theſe experiments, we may aſſume the following reſults as ſufficiently eſtabliſhed.

Combuſtion of Phoſphorus.

From the combuſtion of phoſphorus, as related in the foregoing experiments, it appears, that one pound of phoſphorus requires 1.5 *lib.* of oxygen gas for its combuſtion; and that 2.5 *libs.* of concrete phoſphoric acid are produced.

The quantity of caloric diſengaged by the combuſtion of one pound of phoſphorus, expreſſed by the number of pounds of ice melted during that operation, is - -	100.00000
The quantity diſengaged from each pound of oxygen, during the combuſtion of phoſphorus, expreſſed in the ſame manner, is - -	66.66667
The quantity diſengaged during the formation of one pound of phoſphoric acid, is - - -	40.00000
The quantity remaining in each pound of phoſphoric acid, is * -	0.00000

Combuſtion

* We here ſuppoſe the phoſphoric acid not to contain any caloric, which is not ſtrictly true; but, as I have before obſerved

Combuſtion of Charcoal.

In the combuſtion of one pound of charcoal, 2.5714 *libs.* of oxygen gas are abſorbed, and 3.5714 *libs.* of carbonic acid gas are formed: Hence, the

Caloric diſengaged during the combuſtion of one pound of charcoal *,	96.50000
Caloric diſengaged during the combuſtion of charcoal, from each pound of oxygen gas abſorbed,	37.52823
Caloric diſengaged during the formation of one pound of carbonic acid gas, - - - - -	27.02024
Caloric retained by each pound of oxygen after combuſtion, -	29.13844
Caloric neceſſary for ſupporting one pound of carbonic acid in the ſtate of gas, - - -	20.97960

Combuſtion of Hydrogen Gas.

In the combuſtion of one pound of hydrogen gas, 5.6667 *libs.* of oxygen gas are abſorbed, and

obſerved, the quantity it really contains is probably very ſmall, and we have not given it a value, for want of ſufficient data to go upon.—A.

* All theſe relative quantities of caloric are expreſſed by the number of pounds of ice, and decimal parts, melted during the ſeveral operations.—T.

and 6.6667 *libs*. of water are formed: Hence, the

Caloric disengaged from each *lib*. of hydrogen gas*, - -	295.58950
Caloric disengaged from each *lib*. of oxygen gas, - - -	52.16280
Caloric disengaged during the formation of each pound of water, -	44.33840
Caloric retained by each *lib*. of oxygen after combustion with hydrogen, - - - -	14.50386
Caloric retained by each *lib*. of water, at the temperature of 32°,	12.32823

Of the Formation of Nitric Acid.

When nitrous gas is combined with oxygen gas, so as to form nitric or nitrous acid, a degree of heat is produced, which is much less considerable than what is evolved during the other combinations of oxygen; whence it follows, that oxygen, when it becomes fixed in nitric acid, retains a great part of the heat which

* We are no where told upon what data Mr Lavoisier proceeds for ascertaining the quantity of caloric disengaged during the combustion of each pound of hydrogen gas. In a former note I have supposed that it might be thirteen times as much as that of water; hence it would be 628.1164 instead of the above number.—T.

which it poffeffed in the ftate of gas. It is certainly poffible to determine the q antity of caloric which is difengaged during the combination of thefe two gafes, and confequently to determine what quantity remains after the combination takes place. The firft of thefe quantities might be afcertained, by making the combination of the two gafes in an apparatus furrounded by ice; but, as the quantity of caloric difengaged is very inconfiderable, it would be neceffary to operate upon a large quantity of the two gafes, and in a very troublefome and complicated apparatus. By this confideration, Mr de la Place and I have hitherto been prevented from making the attempt. In the mean time, the place of fuch an experiment may be fupplied by calculations, the refults of which cannot be very far from truth.

Mr de la Place and I deflagrated a convenient quantity of nitre and charcoal in an ice apparatus, and found that twelve pounds of ice were melted by the deflagration of one pound of nitre. We fhall fee, in the fequel, that one pound of nitre is compofed, as under, of

Potafh	7 *oz.*	6 *gros*	51.84 *grs.*	=4515.84 *grs.*
Dry acid	8	1	21.16	=4700.16

The above quantity of dry acid is compofed of

Oxygen

Oxygen	6 *oz.*	3 *gros*	66.34 *grs.*	=3738.34 *grs.*
Azot	1	5	25.82	= 961.82

By this we find, that, during the above deflagration, $145\frac{1}{3}$ *grs.* of carbon * have suffered combuſtion, along with 3738.34 *grs.* or 6 *oz.* 3 *gros* 66.34 *grs.* of oxygen. Hence, ſince 12 *libs.* of ice were melted during the combuſtion, it follows, that one pound of oxygen burnt in the ſame manner would have melted 29.5832 *libs.* of ice. To which if we add the quantity of caloric retained by a pound of oxygen, after combining with carbon to form carbonic acid gas, which was already aſcertained to be capable of melting 29.13844 *libs.* of ice, we ſhall have for the total quantity of caloric remaining in a pound of oxygen, when combined with nitrous gas in the nitric acid, 58.72164; which is the number of pounds of ice the caloric remaining in the oxygen in that ſtate is capable of melting.

We have before ſeen, that, in the ſtate of oxygen gas, it contained at leaſt 66.66667; wherefore it follows, that, in combining with azot to form nitric acid, it only loſes 7.94502. Farther experiments

* From this it appears, that the proportions uſed by Mr Lavoiſier were 1 *lib.* 9216 *grs.* of nitre to 2 *gros* $1\frac{1}{3}$ *grs.* or 145.34 *grs.* of charcoal, though he has not choſen to mention it in direct terms.—T.

experiments upon this ſubject are neceſſary to aſcertain how far the reſults of this calculation may agree with direct fact. This enormous quantity of caloric, retained by oxygen in its combination into nitric acid, explains the cauſe of the great diſengagment of caloric during the deflagrations of nitre; or, more ſtrictly ſpeaking, upon all occaſions of the decompoſition of nitric acid.

Of the Combuſtion of Wax.

Having examined ſeveral caſes of ſimple combuſtion, I mean now to give a few examples of a more complex nature. One pound of wax-taper being allowed to burn ſlowly in an ice apparatus, melted 133.1667 *libs.* of ice. According to my experiments, as given in the Memoirs of the Academy for 1784, p. 606, one pound of wax-taper conſiſts of 0.8228 *libs.* of carbon, and 0.1772 *libs.* of hydrogen.

By the foregoing experiments, the above quantity of carbon ought to melt,	79.39390 *libs.* of ice;
And the hydrogen ſhould melt -	52.37605
In all	131.76995 *libs.*

Thus

Thus we ſee, that the quantity of caloric diſengaged from a burning taper, is nearly conformable to what was obtained by burning ſeparately a quantity of carbon and hydrogen equal to what enters into its compoſition. Theſe experiments with the taper were ſeveral times repeated, ſo that I have reaſon to believe them accurate.

Combuſtion of Olive-Oil.

We included a burning lamp, containing a determinate quantity of olive-oil, in the ordinary apparatus; and, when the experiment was finiſhed, we aſcertained exactly the quantities of oil conſumed, and of ice melted; the reſult was, that, during the combuſtion of one pound of olive-oil, 148.8828 *libs.* of ice were melted. By my experiments in the Memoirs of the Academy for 1784, and of which the following chapter contains an abſtract, it appears, that one pound of olive-oil conſiſts of 0.7896 *libs.* of carbon, and 0.2104 *libs.* of hydrogen. By the foregoing experiments, that quantity of carbon ſhould melt 76.18723 *libs.* of ice, and the quantity of hydrogen in a pound of the oil ſhould melt 62.15053 *libs.* The ſum of theſe two gives 138.33776 *libs.* of ice, which the two conſtituent elements of the oil would have melted, had they ſeparately ſuffered combuſtion,

bustion; whereas the oil had really melted 148.88330 *libs.* which gives an excess of 10.54554 in the result of the experiment, above the calculated result, from data furnished by former experiments.

This difference, which is by no means very considerable, may arise from errors which are unavoidable in experiments of this nature, or it may be owing to the composition of oil not being as yet exactly ascertained: It proves, however, that there is a great agreement between the results of our experiments, respecting the combination of caloric, and those which regard its disengagement.

The following desiderata still remain to be determined; viz. What quantity of caloric is retained by oxygen, after combining with metals to convert them into oxyds; What quantity is contained by hydrogen, in its different states of existence; and, To ascertain with more precision than is hitherto attained, how much caloric is disengaged during the formation of water, as there still remain considerable doubts with respect to our present determination of this point, which can only be removed by farther experiments. We are at present occupied with this inquiry; and, when these several points are well ascertained, which we hope they will soon be, we shall probably be under the necessity of making considerable corrections upon

moſt of the reſults of the experiments and calculations in this chapter. I did not, however, conſider this as a ſufficient reaſon for withholding ſo much as is already known, from ſuch as may be inclined to labour upon the ſame ſubject. It is difficult in our endeavours to diſcover the principles of a new ſcience, to avoid beginning by conjecture; and it is rarely poſſible to attain perfection at the firſt ſetting out.

CHAP.

CHAP. X.

Of the Combinations of Combuſtible Subſtances with each other.

AS combuſtible ſubſtances in general have great affinity for oxygen, they ought likewiſe to attract, or tend to combine with, each other; *Quæ ſunt eadem uni tertio, ſunt eadem inter ſe*; and the axiom is found to be true. Almoſt all the metals, for inſtance, are capable of uniting with each other, and of forming what are called *alloys** in common language. Moſt of theſe, like other chemical combinations, are ſuſceptible of ſeveral degrees of ſaturation. The greater number of alloys are more brittle than the pure metals of which they are compoſed, eſpecially when the metals alloyed together are conſiderably different in their

* This term *alloy*, which we have from the language of the arts, ſerves exceedingly well for diſtinguiſhing all the combinations or intimate unions of metals with each other, and is adopted in our new nomenclature for that purpoſe.—A.

their degrees of fufibility. To this difference in fufibility, part of the phenomena attendant upon *alloyage* are owing; particularly that property of iron called by workmen *hotfhort.* This kind of iron muft be confidered as an alloy or mixture of pure iron, which is almoft infufible, with a fmall portion of fome other metal, which fufes in a much lower degree of heat: So long as this alloy remains cold, and both metals are in a folid ftate, the mixture is malleable; but when heated to a fufficient degree to liquify the more fufible metal, the particles of this liquid metal, which are interpofed between the particles of the folid iron, muft deftroy their continuity, and occafion the alloy to become brittle. The alloys of mercury, with the other metals, have ufually been called *amalgams,* and we fee no inconvenience from continuing the ufe of that term.

Sulphur, phofphorus, and carbon, readily unite with metals. Combinations of fulphur with metals are ufually named *pyrites.* Their combinations with phofphorus and carbon are either not yet named, or have received new names only of late, wherefore we have not fcrupled to change them according to our principles. The combinations of metal and fulphur we call *fulphurets,* thofe with phofphorus *phofphurets,* and thofe formed with carbon *carburets.*

carburets *. These denominations are extended to all the combinations into which the above three substances enter, without being previously oxygenated. Thus, the combination of sulphur with potash, or fixed vegetable alkali, is called *sulphuret of potash*; that which it forms with ammoniac, or volatile alkali, is termed *sulphuret of ammoniac*.

Hydrogen is likewise capable of combining with many combustible substances: In the state of gas, it dissolves carbon, sulphur, phosphorus, and several metals: we distinguish these combinations by the terms *carbonated hydrogen gas*, *sulphurated hydrogen gas*, and *phosphorated hydrogen gas*. The sulphurated hydrogen gas was called *hepatic air* by former chemists; or *fœtid air from sulphur*, by Mr Scheele: The virtues of several mineral waters, and the fœtid smell of animal excrements, chiefly arise from the presence of this gas. The phosphorated hydrogen gas is remarkable for the property, discovered

 by

* In the French nomenclature, these compounds are named *sulphures*, *phosphures*, and *carbures*; but, though these terms may be sufficiently distinguishable from *souffre*, *phosphore*, and *carbone*, they are not, especially the two first, distinct enough in English: I have therefore chosen to borrow the new English terms in the text, from the Latin edition of the new nomenclature, where they are called respectively *sulphurettum*, *phosphorettum*, and *carburettum*.—T.

by Mr Gengembre, of taking fire ſpontaneouſly upon getting into contact with atmoſpheric air, or, what anſwers better, with oxygen gas: This gas has a ſtrong flavour, reſembling that of putrid fiſh; and it is very probable that the phoſphoreſcent quality of fiſh, in the ſtate of putrefaction, ariſes from the eſcape of this ſpecies of gas. When hydrogen and carbon are combined together, without the intervention of caloric to bring the hydrogen into the ſtate of gas, they form oil, which is either fixed or volatile, according to the proportions of hydrogen and carbon in its compoſition *. The chief difference between fixed or fat oils drawn from vegetables by expreſſion, and volatile or eſſential oils, is, that the former contains an exceſs of carbon, which is ſeparated when the oils are heated above the degree of boiling water; whereas the volatile oils, containing a juſt proportion of theſe two conſtituent ingredients, are not liable to be decompoſed by that heat, but, uniting with caloric into the gaſeous ſtate, paſs over in diſtillation unchanged.

In

* We ſhall afterwards ſee, that oil contains oxygen, combined with the above-mentioned ingredients, and that it is a hydro-carbonous or carbono-hydrous oxyd; hence the difference between the various kinds may in part be owing to their different degrees of oxydation, as well as to the proportions of the other ingredients.—T.

In the Memoirs of the Academy for 1784, p. 593. I gave an account of my experiments upon the compoſition of oil and alcohol, by the union of hydrogen with carbon, and of their combination with oxygen. By theſe experiments, it appears that fixed oils combine with oxygen during combuſtion, and are thereby converted into water and carbonic acid. By means of calculation, applied to the products of theſe experiments, we find that fixed oil is compoſed of 21 parts, by weight, of hydrogen combined with 79 parts of carbon. Perhaps the ſolid ſubſtances of an oily nature, ſuch as wax, contain a proportion of oxygen, to which they owe their ſtate of ſolidity. I am at preſent engaged in a ſeries of experiments, which I hope will throw great light on this ſubject.

It is worthy of being examined, whether hydrogen in its concrete ſtate, uncombined with caloric, be ſuſceptible of combination with ſulphur, phoſphorus, and the metals. There is nothing that we know of, which, *à priori*, ſhould render theſe combinations impoſſible; for combuſtible bodies being in general ſuſceptible of combination with each other, there is no evident reaſon for hydrogen being an exception to the rule: However, no direct experiment as yet eſtabliſhes either the poſſibility or impoſſibility of this union. Iron and

zinc are the moſt likely, of all the metals, for entering into combination with hydrogen; but, as theſe have the property of decompoſing water, and as it is very difficult to get entirely free from moiſture in chemical experiments, it is hardly poſſible to determine whether the ſmall portions of hydrogen gas, obtained in certain experiments with theſe metals, were previouſly combined with the metal in the ſtate of ſolid hydrogen, or if they were produced by the decompoſition of a minute quantity of water. The more care we take to prevent the preſence of water in theſe experiments, the leſs is the quantity of hydrogen gas procured; and when very accurate precautions are employed, even that quantity becomes hardly ſenſible.

However this inquiry may turn out reſpecting the power of combuſtible bodies, as ſulphur, phoſphorus, and metals, to abſorb hydrogen, we are certain that they only abſorb a very ſmall portion; and that this combination, inſtead of being eſſential to their conſtitution, can only be conſidered as a foreign ſubſtance, which contaminates their purity. It is the province of the advocates* for this ſyſtem to prove

* By theſe are meant thoſe ſupporters of the phlogiſtic theory, who conſider hydrogen, or the baſe of inflammable air, as the phlogiſton of the celebrated Stahl.—T.

prove by decisive experiments, the real existence of this combined hydrogen, which they have hitherto only done by conjectures founded upon suppositions.

CHAP.

CHAP. XI.

Obſervations upon Oxyds and Acids with compound Baſes,—and on the Compoſition of Vegetable and Animal Subſtances.

WE have, in Chap. V. and VIII. examined the products reſulting from the combuſtion of the four ſimple combuſtible ſubſtances, ſulphur, phoſphorus, carbon, and hydrogen: We have ſhewn, in Chap. X. that the ſimple combuſtible ſubſtances are capable of combining with each other into compound combuſtible ſubſtances, and have obſerved that oils in general, and particularly the fixed vegetable oils, belong to this claſs, being compoſed of hydrogen and carbon. It remains, in this chapter, to treat of the oxygenation of theſe compound combuſtible ſubſtances, and to ſhow that there exiſt acids and oxyds having double and triple baſes. Nature furniſhes us with numerous examples of this kind of combinations, by means of which, chiefly, ſhe is

is enabled to produce a vaſt variety of compounds, from a very limited number of elements, or ſimple ſubſtances.

It was long ago well known, that, when muriatic and nitric acids were mixed together, a compound acid was formed, having properties quite diſtinct from thoſe of either of the acids taken ſeparately. This acid was called *aqua regia*, from its moſt celebrated property of diſſolving gold, called *king of metals* by the alchymiſts. Mr Berthollet has diſtinctly proved, that the peculiar properties of this acid ariſe from the combined action of its two acidifiable baſes, and, for this reaſon, we have judged it neceſſary to diſtinguiſh it by an appropriate name: that of *nitro-muriatic* acid appears extremely applicable, from its expreſſing the nature of the two ſubſtances which enter into its compoſition.

This phenomenon, of a double baſe in one acid, which had formerly been obſerved only in the nitro-muriatic acid, occurs continually in the vegetable kingdom; in which a ſimple acid, or one poſſeſſed of a ſingle acidifiable baſe, is very rarely found. Almoſt all the acids procurable from this kingdom have baſes compoſed of carbon and hydrogen, or of carbon, hydrogen, and phoſphorus, combined with more or leſs oxygen. All theſe baſes, whether double or triple, are likewiſe found in the ſtate of oxyds, having

having leſs oxygen than is neceſſary to give them the properties of acids. The acids and oxyds from the animal kingdom are ſtill more compound, as their baſes generally conſiſt of a combination of carbon, phoſphorus, hydrogen, and azot.

As it is but of late that I have acquired any clear and diſtinct notions of theſe ſubſtances, I ſhall not in this place enlarge much upon the ſubject, which I mean to treat of very fully in ſome memoirs I am preparing to lay before the Academy. Moſt of my experiments are already performed; but, to be able to give exact reports of the reſulting quantities, it is neceſſary that they be carefully repeated, and increaſed in number: Wherefore, I ſhall only give a ſhort enumeration of the vegetable and animal acids and oxyds, and terminate this article by a few reflections upon the compoſition of vegetable and animal bodies.

Sugar, mucus, under which term we include the different kinds of gums, and ſtarch, are vegetable oxyds, having hydrogen and carbon combined, in different proportions, as their radicals or baſes, and united with oxygen, ſo as to bring them to the ſtate of oxyds. From this ſtate of oxyds, they are capable of being changed into acids, by the addition of a freſh quantity of oxygen; and, according to the degrees of oxygenation,

tion, and the proportion of hydrogen and carbon in their bafes, they form the feveral kinds of vegetable acids.

It would be eafy to apply the principles of our nomenclature to give names to thefe vegetable acids and oxyds, by ufing the names of the two fubftances which compofe their bafes: They would thus become hydro-carbonous acids and oxyds. In this way, we might indicate which of their elements exifted in excefs, without circumlocution, after the manner ufed by Mr Rouelle, for naming the vegetable extracts: He calls thefe extracto-refinous, when the extractive matter prevails in their compofition, and refino-extractive, when they contain a larger proportion of refinous matter. Following that plan, and by varying the terminations according to the formerly eftablifhed rules of our nomenclature, we have the following denominations: Hydro-carbonous, hydro-carbonic, carbono-hydrous, and carbono-hydric, oxyds. And, for the acids: Hydro-carbonous, hydro-carbonic, oxygenated hydro-carbonic; carbono-hydrous, carbono-hydric, and oxygenated carbono-hydric.

It is probable, that the above terms would fuffice for indicating all the varieties in nature, and that, in proportion as the vegetable acids

becomes

become well underſtood, they will naturally arrange themſelves under theſe denominations. But, though we know the elements of which theſe are compoſed, we are as yet ignorant of the proportions of theſe ingredients, and are ſtill far from being able to claſs them in the above methodical manner; wherefore, we have determined to retain the old names proviſionally. I am ſomewhat farther advanced in this inquiry than at the time of publiſhing our conjunct eſſay upon chemical nomenclature; yet it would be improper to draw decided conſequences from experiments not yet ſufficiently preciſe: Though I acknowledge that this part of chemiſtry ſtill remains in ſome degree obſcure, I muſt expreſs my expectations of its being very ſoon elucidated.

I am ſtill more forcibly neceſſitated to follow the ſame plan in naming the acids, which have three or four elements combined in their baſes; of theſe we have a conſiderable number from the animal kingdom, and ſome even from vegetable ſubſtances. Azot, for inſtance, joined to hydrogen and carbon, form the baſe or radical of the Pruſſic acid: we have reaſon to believe that the ſame happens with the baſe of Gallic acid; and almoſt all the animal acids have their baſes compoſed of azot, phoſphorus, hydrogen, and carbon. Were we to endeavour

to

to expreſs at once all theſe four component parts of the baſes, our nomenclature would undoubtedly be methodical; it would have the property of being clear and determinate: but this aſſemblage of Greek and Latin ſubſtantives and adjectives, which are not yet univerſally admitted by chemiſts, would have the appearance of a barbarous language, difficult both to pronounce and to be remembered. Beſides, this part of chemiſtry being ſtill far from that accuracy it muſt ſoon attain, the perfection of the ſcience ought certainly to precede that of its language; and we muſt ſtill, for ſome time, retain the old names for the animal oxyds and acids. We have only ventured to make a few ſlight modifications of theſe names, by changing the termination into *ous*, when we have reaſon to ſuppoſe the baſe to be in exceſs, and into *ic*, when we ſuſpect that oxygen predominates.

The following are all the vegetable acids hitherto known:

1. Acetous acid.
2. Acetic acid.
3. Oxalic acid.
4. Tartarous acid.
5. Pyro-tartarous acid.
6. Citric acid.
7. Malic acid.

8. Pyro-mucous acid.
9. Pyro-lignous acid.
10. Gallic acid.
11. Benzoic acid.
12. Camphoric acid.
13. Succinic acid *.

Though all theſe acids, as has been already ſaid, are chiefly, and almoſt entirely compoſed of hydrogen, carbon, and oxygen, yet properly ſpeaking, they contain neither water, carbonic acid, nor oil, but only the elements neceſſary for forming theſe ſubſtances. The power of affinity reciprocally exerted by the hydrogen, carbon, and oxygen, in theſe acids, is in a ſtate of equilibrium, that is, only capable of exiſting in the ordinary temperature of the atmoſphere: For, when they are heated but a very little above the temperature of boiling water, this equilibrium is deſtroyed; part of the oxygen and hydrogen unite, and form water; part of the carbon and hydrogen combine into oil; part of the carbon and oxygen unite to form carbonic acid; and, laſtly, there generally remains a ſmall portion of carbon, which, being in exceſs with reſpect to the other ingredients, is left free. I mean

* To theſe is lately added the Suberic acid; an account of which is inſerted in this edition, Part II. Sect. xlvii. See Contents.—T.

mean to explain this ſubject ſomewhat further in the ſucceeding Chapter.

The oxyds of the animal kingdom are hitherto leſs known than thoſe from the vegetable kingdom, and their number as yet is not at all determined. The red part of the blood, lymph, and moſt of the ſecretions, are true oxyds, under which point of view it is very important to conſider them. We are only acquainted with ſix animal acids, ſeveral of which, it is probable, approach very near each other in their nature, or, at leaſt, differ only in a ſcarcely ſenſible degree. I do not include the phoſphoric acid amongſt theſe, becauſe it is found in all the kingdoms of nature. They are,

1. Lactic acid.
2. Saccho-lactic acid.
3. Bombic acid.
4. Formic acid.
5. Sebacic acid.
6. Pruſſic acid *.

The connection between the conſtituent elements of the animal oxyds and acids is not more permanent than in thoſe from the vegetable kingdom, as a ſmall increaſe of tempera-

ture

* To theſe muſt now be added the Zoonic acid; an account of which is added to this Edition, Part II, Sect. XLVI.—T.

ture is ſufficient to overturn the equilibrium. I hope to render this ſubject more diſtinct in the following Chapter than has been done hitherto.

ADDITIONAL

Additional Section by the Translator.

Of the Proximate Elements of Vegetable and Animal Subſtances *.

IN addition to the foregoing ſhort, yet clear, account of the ultimate chemical compoſition of vegetable and animal ſubſtances, the tranſlator preſumes it may be uſeful to give an abſtract of what are termed the *proximate* elements of thoſe bodies. Theſe are ſuch products of animal and vegetable ſubſtances, as are formed by the combinations of their ultimate or ſimple elements, and the mixture or combination of theſe compounds with oxygen; and moſt, if not all of them, are carbono-hydric or hydro-carbonic radicals, with more or leſs oxygen combined; ſome of them having an addition of azot, or other ſimple element, in the compoſition of the radical. Theſe proximate elements arrange themſelves, according to the preſent ſtate of our knowledge, into a limited number of what may be called *genera*, each of which have their diſtinguiſhing chemical and ſenſible properties; and according as each, particularly from the vegetable

* The whole of this Section is added by the Tranſlator to this fifth edition.—T.

getable kingdom, is more or leſs mixed with other proximate elements, the genus is farther diviſible into ſpecies, which may be denominated from the particular vegetable or animal from which it is procured. Thus, ſugar is a proximate element of many vegetables, and ſo far is a genus in which honey is likewiſe included: But, as procurable from ſugar-cane, maple, and many other vegetables, it poſſeſſes very different taſtes and flavours, probably owing to the mixture or combination of other proximate elements, which communicate ſpecific differences. This curious branch of chemiſtry is only in its infancy; but promiſes very intereſting, and probably important reſults.

Theſe proximate elements are procured by expreſſion; by infuſion in water, alcohol, or other menſtrua, hot or cold; by diſtillation with water or alcohol; by fermentation, putrefaction, deſtructive diſtillation, oxygenation by means of decompoſible acids, combuſtion, and other methods of analyſis: And, by ſome of thoſe analytical methods, they are farther reſolvable into the ultimate or ſimple chemical elements.

§ 1. *Proximate Elements of Vegetables.*

1. *Mucilage* or *Gum* exudes naturally from many vegetables in a very pure ſtate, and is procurable

procurable from others by watery infufion. When pure, it is folid, brittle, and fomewhat tranfparent; perfectly inodorous, and almoft totally infipid. It is foluble in water, forming a vifcid or glutinous liquid: Infoluble in oil or alcohol. When triturated with oil or refin, it renders them perfectly diffufible in water. Its folution does not undergo vinous fermentation; but, efpecially when dilute, with accefs of air, it oxygenates, and is converted into pyromucous acid. Treated with nitric acid, it becomes ftrongly oxygenated, and oxalic acid is formed; with oxymuriatic acid, nitric acid is produced. By deftructive diftillation, pyromucous acid, carbonic acid, hydro-carbonic gas, and ammoniac, come over; and the refiduum confifts of charcoal containing lime. Its ultimate elements, therefore, are hydrogen, carbon, azot, lime and oxygen.

2. *Starch* or *Fecula* is a principal product from farinaceous grains and roots, from which it is procured by trituration and maceration in a large quantity of cold water; being thus feparated from the other materials, in a light pulverulent form, by decantation and fubfidence, and is, laftly, dried for ufe. At firft, it is frequently grey, and often flocculent; but, by allowing the liquid in which it fwims to become four, the matters which contaminate its purity are oxygenated and diffolved. When pure, it

is a light, white, ſoft powder; inodorous and taſteleſs; diffuſible, but inſoluble, in cold water: in hot water, it diſſolves into a gelatinous liquid, which coagulates when cold. If this jelly is dried, it becomes hard, tenacious, horny, and ſomewhat tranſparent, and may be again ſoftened by cold, or diſſolved by hot water.

Starch is not ſoluble in alcohol. By fermentation, eſpecially after malting, it is convertible into ſaccharine matter and vinous liquor, from which alcohol is procurable by diſtillation. By farther fermentation, it becomes ſour, forming *aleager* or common vinegar. With nitric acid, oxalic and malic acids are formed. In cloſe veſſels, a large quantity of acid liquor diſtils over, with carbonic acid and hydro-carbonic gas, leaving a reſiduum of charcoal: Its ultimate elements are carbon, hydrogen, and oxygen.

3. *Sugar* or *Saccharine Matter* is often mixed in vegetables with the former, and which may be converted into it by the malting proceſs. It exiſts likewiſe naturally, and in great abundance, in the peculiar juices of many vegetables; the ſugar-cane eſpecially, beet, carrot, parſnip, ſugar maple, and many others, containing a conſiderable quantity of ſaccharine juice. To procure ſugar in a pure ſtate, the ſaccharine juice is mixed with lime, to neutralize the oxalic acid with which it uſually abounds,

abounds, and which would prevent its concretion. It is then evaporated, and the fugar runs into fmall irregular cryftals. It is afterwards purified, by boiling with lime-water, and blood, or whites of eggs, is laded into conical moulds of baked clay, and dried in a ftove.

Pure fugar is white and perfectly fweet, without any odour or peculiar flavour. It is foluble in water or alcohol, from which it cryftallizes by evaporation. Its folution in water paffes readily into the vinous fermentation, from which alcohol may be diftilled; and by farther oxygenation, it changes to acid. Oxygenated by means of nitric acid, it is converted into oxalic acid. By deftructive diftillation, it gives over a large quantity of acid liquor, with empyreumatic oil, carbonic acid, and hydro-carbonic gas, leaving a refiduum of charcoal. Its ultimate elements are therefore the fame with thofe of ftarch, carbon, hydrogen, and oxygen; from which, perhaps, it differs in containing more oxygen.

Honey is fimilar to fugar, and probably confifts of the fame ultimate elements. It is originally formed in vegetables; but feems to undergo fome preparation or change in the honey-bags of the bees.

4. *Vegetable gluten* is chiefly procurable from flour of wheat, wafhed in water. The foluble matter diffolves, the fecula is diffufed, and the

gluten remains in a fibrous, elaſtic, viſcid maſs. It is inſipid, inodorous, of a greyiſh colour, inſoluble in water, and ſlightly ſoluble in alcohol. It diſſolves in acids, and in alkaline ſolutions; being precipitated from acid ſolutions by the alkalies, and from alkaline ſolutions by the acids. On expoſure to a moiſt atmoſphere, it putrefies like animal ſubſtances. With nitric acid, it is changed to oxalic acid, a large quantity of azotic gas being diſengaged. In cloſe veſſels, it affords a large quantity of ammonia, with carbonic acid and empyreumatic oil. Hence, its ultimate elements are carbon, hydrogen, azot, and oxygen.

5. *Vegetable Albumen* is combined or mixed with gluten in flour of wheat or other grain. It diſſolves in cold water, from which it ſeparates by heat, or the addition of alcohol, in light flakes. It is ſoluble in the alkalies, is liable to putrefaction, and gives over ammonia in deſtructive diſtillation. Hence, its ultimate elements are ſimilar to thoſe of gluten, from which it differs in being ſoluble in cold water.

Gluten and albumen ſeem to form the chief ingredients of yeaſt or barm; and from them it probably ariſes, that wheaten bread undergoes the vinous fermentation, by which it is raiſed, or rendered light and porous, and does not ſo readily become ſour as the bread from other grain.

6. *Fixed*

6. *Fixed oil* is moſtly procured from the fruits or ſeeds of vegetables, by expreſſion, or by decoction with water. When pure, it is inodorous, and almoſt perfectly inſipid; but is often mixed with the mucilaginous or extractive matter of the vegetable from which it is extracted; from which it acquires taſte and odour, and by which the oils of particular vegetables are diſtinguiſhed from each other. Cold-drawn oil is more pure than when expreſſed with the aid of heat, or extracted by decoction. Fixed oils are thick and unctuous, lighter than water, congeal by expoſure to cold, and ſome are even concrete in the uſual temperature. Fixed oil is inſoluble in water or alcohol. Expoſed to warm air, it abſorbs oxygen, becomes thick and coloured, acquires a diſagreeable odour, and a ſharp unpleaſant taſte, changing to what is called rancceſcence. It boils at 600° of Fahrenheit, is changed into vapour which is readily inflamed, and is thereby converted into water and carbonic acid. Without materially raiſing its temperature, it burns imperfectly in a common lamp, giving out a conſiderable quantity of ſmoke, which conſiſts of carbonaceous matter and empyreumatic oil. With a very ſlender wick, or a cylindrical one properly managed, it is almoſt totally converted into water and carbonic acid, as in the combuſtion of its vapour. By diſtillation in cloſe veſſels, it loſes its mildneſs

neſs and unctuoſity, becomes more limpid and volatile, and a portion of carbonaceous matter is left in the retort. Tranſmitted through an ignited tube, it is converted into carbonic acid, and hydro-carbonic gas. Sulphuric acid renders it black; part of the oxygen from the acid combines with the hydrogen of the oil, carbonaceous matter is depoſited, and a thickiſh liquid, having a hepatic ſmell, is formed, which has not hitherto been analyzed, but which may probably contain ſulphur, or its oxyd, combined with a part of the oil, in a ſtate ſimilar to petroleum. Nitric acid thickens expreſſed oil; and, when empyreumatic or rancid, from expreſſion by heat or otherwiſe, readily ſets it on fire. Oxymuriatic acid thickens it, and in ſome inſtances renders it concrete. All theſe changes deſerve minute inveſtigation.

Soap is formed by the union of fixed oil with the fixed alkalies, potaſh or ſoda, in a cauſtic or pure ſtate, and forms a ſaponaceous compound with ammonia. Soap is ſoluble in water and alcohol, and is decompoſed by all the acids, and by moſt ſalts having earthy or metallic baſes. When decompoſed by heat, or deſtructive diſtillation, ſoap produces water, empyreumatic oil, and ammonia *. The oil which ſeparates from

* The Tranſlator only pretends to give theſe facts from chemical writers. This decompoſition of ſoap is certainly

from ſoap, when decompoſed by the acids or neutral ſalts, is ſo far changed as to be ſoluble in alcohol. When ſoap is decompoſed by earthy or metallic ſalts, which takes place by double affinity, the acid unites with the alkali of the ſoap, and the oil combines with the earthy baſis, or the metallic oxyd of the neutral ſalt.

Expreſſed oil unites, by boiling, with ſulphur into a compound which has an exceſſively offenſive odour, and a very diſagreeable acrid taſte, uſually called *balſam of ſulphur*. It likewiſe combines with phoſphorus, and unites with gum, reſin, and ſeveral other vegetable products. With mucilage it forms a milky compound, called in pharmacy *emulſion*, and with ſugar what is called *oleo-ſaccharum*. The ultimate elements of expreſſed oil, ſo far as is yet known, are carbon, hydrogen, and oxygen.

7. *Volatile* or *Eſſential Oil* is procurable from a variety of parts of many vegetables, uſually by

certainly not ſufficiently explained, as no account is given of the fixed alkalies. Neither is it determined whence the ammonia of this decompoſition proceeds. If from the alkali, and no other ſource appears, a proper inveſtigation of this experiment ſhould lead to the analyſis of fixed alkali. At the ſame time, it is known, that the ſoap of commerce contains animal oils, which certainly contain ammonia, or at leaſt azot, one of its conſtituent ingredients.—T.

by diſtillation with water. A ſmall part unites with the diſtilled water, and the reſt ſwims, for the moſt part, on the ſurface, though a few of theſe oils are heavier than water. Sometimes this oil is contained in diſtinct veſicles of the vegetable, and is got by expreſſion. In volatile oil, the peculiar odour of each plant is generally found, from which the term *eſſential* is derived; and, although from ſome highly odorant vegetables, very little volatile oil is procurable, and a conſiderable quantity from ſuch as have little odour, it would appear that the ſmell emitted by odorant vegetables is produced by its natural evaporation.

Volatile oil is odorous, ſapid, and pungent. It is for the moſt part liquid, even in low temperatures, though ſome congeal in moderate degrees of cold, and others are concrete in the ordinary temperatures. It diſſolves ſparingly in water; to which it communicates its peculiar odour, taſte, and pungency; as likewiſe to alcohol and proof-ſpirits, in which it is more abundantly ſoluble. Both theſe ſolutions are uſually accompliſhed by diſtillation, but may likewiſe be formed by other means. That with water is called, in pharmacy, *ſimple diſtilled water*, or merely water of the peculiar vegetable; with proof-ſpirit or alcohol, it gets the name of *compound diſtilled water*, or ſpirit of the vegetable; when in large quantity, combined with alcohol,

it

it is denominated *essence* or *quintessence*, and is then more readily soluble in water, and in larger proportion.

Exposed to the air, volatile oils gradually lose their peculiar odours, are thickened, and finally become concrete, resembling resins; often depositing acid crystals, and sometimes granules resembling camphor. By moderate heat, they are volatilized without change; but are partially decomposed by greater heat than is necessary for distillation. Heated in contact with air, they are more volatile, more readily inflammable, and produce more water in combustion, than fixed oils, and consequently contain a larger proportion of hydrogen. By the acids, they are oxydated, becoming black with sulphuric acid. Nitric acid, especially when mixed with sulphuric, readily sets them on fire. Dilute nitric acid and oxymuriatic, convert them into resinous substances by oxydation. They combine with, or dissolve, sulphur, phosphorus, resin, and camphor; but combine difficultly and sparingly with the alkalies. By sugar, mucilage, and some other vegetable products, they are rendered miscible with water, in the state of emulsion. Previously united with alcohol, into what has been called *essence*, they are considerably soluble in water. Their ultimate elements seem the same with those of fixed oils, carbon, hydrogen, and

and oxygen; perhaps in different proportions, and different degrees of oxydation.

The particular odours of volatile oils, and of all odorant bodies, have been ſuppoſed owing to the preſence of a diſtinct element or principle, called *aroma* or *ſpiritus rector*: But, as there is no evidence of its exiſtence, as every diſtinct odour would, in this caſe, require a ſeparate ſpecies of aroma, and as every peculiar ſenſible quality might with equal propriety be referred to a peculiar hypothetic element, ſuch as bitterneſs, narcotic power, laxative or emetic quality, and ſo forth, it is certainly unphiloſophical to aſſume any ſuch element to exiſt. Beſides, we know that metals poſſeſs odour and ſapidity, and that both may be given to the moſt inſipid and inodorous vegetable and animal products, merely by changing the ſtate of combination of their ultimate elements, by means of heat or otherwiſe.

8. *Camphor* is chiefly procured by diſtillation or ſublimation from the wood of laurus camphora; but is likewiſe found in ſome other vegetables, and is depoſited from the volatile oils of ſeveral plants when long kept. It is white, ſemi-tranſparent, ſolid, tenacious, and ſomewhat cryſtalline, having a pungent fragrance and taſte. It is highly inflammable, extremely volatile, and ſublimes unchanged by moderate heat; is largely ſoluble in alcohol and oils,

but

but ſparingly in water or proof-ſpirit, in which it becomes more ſoluble by trituration with magneſia. Sulphuric, muriatic, fluoric, and ſulphurous acids, diſſolve it without change. Diſſolved in nitric acid, an oily-looking liquor ſwims on the ſurface, from which water precipitates the camphor. When nitric acid is frequently diſtilled from camphor, it is entirely converted into camphoric acid. Camphor does not combine with the alkalies. Mixed with clay, or any ſubſtance which oppoſes its extreme volatility, it becomes able to undergo conſiderable heat, by which it is decompoſed, giving over a volatile, pungent, and highly fragrant oil, exactly ſimilar to eſſential oils: At the ſame time, camphoric acid, with ſmall quantities of carbonic acid, and hydro-carbonic gas, come over, and a ſmall portion of carbonaceous matter remains. Its ultimate elements probably are carbon, hydrogen, and oxygen, perhaps having more carbon and oxygen than the volatile oils.

9. *Benzoin.* As this vegetable production affords a peculiar acid by ſublimation, and even by other means of decompoſition, it might deſerve inveſtigation, and a ſeparate place perhaps, as legitimately as camphor and ſome other vegetable products: But, not having been hitherto ſubmitted to chemical analyſis, we can only here recommend it to the notice of chemiſts.

10. *Amber.* It is doubtful to which of the three kingdoms of nature this peculiar ſubſtance is indebted for its origin. It is found on the ſea-ſhore, eſpecially in Pruſſia, and is dug from the earth: But has been ſuppoſed the work of inſects, and to be prepared by them from the reſinous exudations of ſome of the fir or pine tribe. Like benzoin, it gives out a peculiar acid by ſublimation: But its chemical analyſis has not hitherto been inveſtigated.

11. *Wax* is collected by bees from the flowers and other parts of vegetables, but probably undergoes ſome change from the animal powers of theſe inſects. In its rude ſtate, it is of various ſhades of yellow or brown, having conſiderable fragrance, and ſome taſte; being hard, tenacious, plaſtic, and ſoftening or melting by heat. When purified by bleaching, by which probably its carbon is partly ſeparated and ſome oxygen added, it becomes perfectly white and opake, and rather harder and more tenacious than before.

Wax is fuſible, and burns in a high temperature, or with the aid of a wick, reſolving by combination with oxygen into water and carbonic acid. By deſtructive diſtillation, it gives over a thick empyreumatic oil, and an acid liquor, leaving a carbonaceous reſiduum. Hence its ultimate elements are carbon, hydrogen, and oxygen; and it ſeems to have the ſame relation

tion with fixed oils that camphor has to the volatile.

12. *Refin* is hardly ever procured pure from vegetables, being generally mixed or combined with volatile oil, gum, or other matter. The turpentines, which are procured by exudation, or tapping, from many trees of the fir and pine tribes, and the various balfams, are refin diffolved in effential oil. Tar is turpentine procured by rude diftillation, mixed with carbonaceous and other matters, and pitch is tar boiled to greater confiftence.

By diftillation, the effential oils are feparated from the refin in the turpentines, a fmall portion of benzoic acid being ufually procured at the fame time. When diftilled with the affiftance of water, and not pufhed too far, pure refin is left in the retort; but if the fire is a little urged, the refin is partially decompofed, and acquires colour from the prefence of free carbon, in which ftate it is called Colophony.

In many vegetables, refin is naturally united with gum, forming gum-refin or refinous gum, according as one or other prevails. Thefe are foluble in water or proof-fpirit; or may be feparated by diffolving the refinous part in alcohol, and the gummous in water. In other vegetables, the gum and refin are farther mixed with extractive matter, fugar, ftarch, and other products. Moft of the pure refins are foluble

in alcohol, eſſential oil, and fixed oil, though ſome require the previous aſſiſtance of ether, but theſe probably have ſome difference in their compoſition, by exceſs or paucity of one or other of the ultimate elements. None of the reſins are ſoluble in water, or only in a ſlight degree like camphor and eſſential oils. They are moſtly ſapid and odorous; though ſome, as copal and ſandarach, are almoſt devoid of either quality.

Reſin is ſolid, tenacious, plaſtic, and conſiderably tranſparent; being brittle and eaſily pulverized in a moderate temperature. It is eaſily fuſed, and readily inflammable, giving out carbonic acid and water. In cloſe veſſels, it gives over empyreumatic oil, acid liquor, carbonic acid, and hydro-carbonic gas, leaving carbonaceous matter. With alkalies it forms ſoap, and is much uſed in manufacture for that purpoſe, being a chief ingredient in yellow ſoap, and that to which it owes its ſolidity. Its ultimate elements are carbon, hydrogen and oxygen, probably having more oxygen than eſſential oils.

13. *Extract*, or *Extractive Matter*, is a product from vegetables, which conſiderably reſembles gum-reſin, of which perhaps it is only a modification, by mixture or combination with other proximate principles, and ſome ſaline compounds. It is obtainable from moſt, if not all,

all, vegetables, by maceration in water, and evaporation of the infusion. It is soluble in water, alcohol, or proof-spirit, but not in ether; and possesses the sapid, odorant, and other sensible qualities of the vegetable from which it is procured. By long exposure to the air, or rapidly by means of the boiling heat, and by oxymuriatic acid, it absorbs oxygen, becomes insipid and inodorous, and insoluble in water. By distillation in close vessels, it gives over empyreumatic oil, acid liquor, and a small quantity of ammonia: Hence its ultimate elements are carbon, hydrogen, azot, and oxygen.

14. *Caoutchouc*, or *Elastic Gum* *, is procured from several plants by incision; at first of a thick milky consistence, becoming concrete by exposure to the air. It is then of various shades, semi-transparent, extremely tough, flexible when a little warm, and very highly elastic. It is extremely inflammable, even when cold. By considerable heat it is softened, and loses its elasticity. Water does not dissolve it, but permanently softens its texture. It is insoluble in alcohol or proof-spirit, but dissolves in ether, fixed and volatile oils, and in rectified petroleum. It is oxygenated and altered in its appearance by sulphuric and nitric acids. In close vessels, it gives over empyreumatic oil,

 carbonic

* Likewise termed India rubber, or lead-eater.—T.

carbonic acid, hydrocarbonic gas, and ammonia: Its ultimate elements, therefore, are carbon, hydrogen, azot, and oxygen.

15. *Tanin*, or *the Aſtringent Principle*, is procured from oak-bark, galls, or other aſtringent vegetable, by infuſion in water, but blended or combined with gallic acid, with which till lately it has been confounded. By a firſt infuſion of aſtringent vegetable in hot water, moſt of the tanin contained is diſſolved, along with a ſmall portion of gallic acid. A ſecond infuſion affords gallic acid with very little tanin; and a third infuſion contains gallic acid almoſt pure. Hence, ſpent tan-bark contains gallic acid, and no tanin, or extremely little.

If to an infuſion of vegetable aſtringent, a ſolution of animal glue be added, the glue and tanin combine into an inſoluble precipitate, and a ſolution of pure gallic acid is procured by filtration.

To procure the tanin free from gallic acid, add a ſolution of muriat of tin to the aſtringent infuſion. The oxyd of tin combines with the tanin, forming an inſoluble precipitate, and the two acids remain in the liquid. By filtration and careful waſhing, the acids are ſeparated from the inſoluble compound, which is then to be diffuſed in water, through which a ſtream of ſulphurated hydrogen gas is made to flow. This gas combines with the oxyd of tin, forming an

inſoluble

insoluble precipitate, and the tanin is left pure, now in solution.

Tanin has no acid properties whatever; but eminently possesses those which were formerly attributed to gallic acid, or rather to the mixture or combination of that acid and tanin. It forms a dark precipitate with red oxyd of iron; darker than that with common astringent infusion, and much darker than that produced by gallic acid. By evaporation, it becomes a solid extractive mass, of a brown colour, with a bitter rough styptic or astringent taste, and is soluble in water. With gelatin or animal glue, it forms an insoluble compound; which diffused among the fibres of skins, renders them dense, thick, insoluble, less permeable to moisture, and not liable to putrefaction: In short, it converts them into leather, or tans them, which is its peculiar property, and from which its name is formed. Perhaps the gallic acid, contained in common astringent infusion or tan, assists the tanning process, by deoxydating the skin, and bringing it more to the state of animal glue. With acids, tanin forms insoluble compounds.

16. *Colouring matter* has been supposed a peculiar proximate principle of vegetables, though colour certainly belongs to several of their products already noticed; and if separate from the other products or proximate principles, it must be various in its composition, from the differ-

ence of colours producible from different vegetables, and the different properties of colours in fixation or permanence, by means of mordants or precipitants. Though, therefore, colouring matter does not properly belong to this ſection, it is here introduced as forming a very intereſting ſubject of diſquiſition, but of which our limits cannot admit the inveſtigation. It involves the whole art of dying by means of vegetable ſubſtances, and the art of making vegetable pigments.

Animal ſubſtances have a more ready attraction for colouring matter than vegetable materials, and retain it more permanently *: Hence ſilk and woollen fabrics are more eaſily and permanently dyed than thoſe of cotton or linen. Various mordants or precipitants are employed, to form inſoluble compounds with colouring matter, to fix it in the dyed ſubſtance, and often likewiſe to modify the colour. Argil, metallic oxyds, gallic acid or rather tanin, gelatin, and gum, are among the principal of theſe mordants or precipitants; and are employed, either by previous combination with the ſubſtance to be dyed, to make it take in and fix the colour; after

* Hence I ſhould ſuſpect, that colouring matter is nearly allied to tanin, or is intimately combined with it; and th.. the fixity of dye-ſtuffs may depend on their containing a ſufficiency of tanin.—T.

after the colouring matter has been united with the dyed ſubſtance, to fix or heighten or modify the colour; or, by previous combination with the dying material, to make it proper for combining with the ſubſtance to be dyed. The formation of vegetable lakes or pigments, is effectuated by the combination of ſome mordant or precipitant with the colouring material in ſolution, which cauſes it to precipitate in an inſoluble or difficultly ſoluble compound. The preparation of indigo, woad and other dye-ſtuffs is of this nature, in which oxygen ſeems the precipitant; and the act of dying with theſe preparations conſiſts, probably, in deoxydating them, in the firſt place, to render them ſoluble, and afterwards reſtoring oxygen to give back their colour, and fix them properly in the dyed ſtuffs.

17. *Ligneous fibre*, may be conſidered as the ſkeleton or ſolid baſis of plants, to which all the other products or proximate elements are naturally attached. It is inſipid and inodorous, and inſoluble either in water, alcohol or oils. By oxygenation, nitrid acid converts it into oxalic and malic acids; and it is decompoſed by other acids. By deſtructive diſtillation, it gives over pyrolignous acid, carbonic acid, and hydrocarbonic gas, leaving a large carbonaceous reſiduum; and conſequently conſiſts of carbon, hydrogen, and oxygen.

18. *Charcoal* is any vegetable fubftance deprived of all volatile parts by the force of heat, or the refiduum left in all deftructive diftillations. It is likewife procurable by fimilar means from a variety of animal fubftances, and is even found in fome mineral productions. Properly fpeaking, thefe ought to be called carbonaceous matters, as charcoal, in ftrict language, is the refiduum from wood or other vegetable fubftance, after deftructive diftillation in a red heat. The charcoal of commerce is rudely prepared, in a manner fimilar to the above, by flow incineration in clofed heaps. For chemical purpofes, it is formed by fubjecting wood, or other vegetable fubftance, to intenfe, or at leaft full red heat, without accefs of air.

When properly prepared, charcoal is light, folid, fhining, brittle, porous, fonorus, infipid, inodorous, and perfectly black. It readily abforbs moifture, and even large quantities of the different permanent gafes, without appearing to be changed in its fenfible properties; though chemically it is very materially altered. Hence, before fubjecting charcoal to any chemical inveftigation, the neceffity of keeping it long in a full red heat, to expel thofe foreign admixtures; and, without expofure to air, to prevent its combuftion. Soot is charcoal in powder, mixed or combined with various other vegetable or animal products, according to the fubftance from

which

which it is procured. Lamp-black is the ſoot of very impure animal or vegetable oils. Ivory-black is bones burnt, to blackneſs only, in cloſe veſſels.

When charcoal is ſet on fire, or raiſed to the temperature of ignition in contact with air, it is almoſt entirely converted into carbonic acid. What remains under the name of aſhes, conſiſts of a ſmall quantity of earth, moſtly lime and magneſia, often combined with ſome acid, and containing a ſmall portion of potaſh or ſoda, or both, and ſome minute particles of neutral ſalts.

By a ſomewhat different mode of incinerating vegetable ſubſtances, with more free acceſs of air, the charcoal is burnt off, and the reſiduum conſiſts chiefly of alkali, potaſh, or ſoda, or a mixture of theſe, according to the vegetable which is incinerated, together with the earthy and ſaline matters already mentioned. As, in theſe different methods of incineration, the product of alkali is very different, more abundant in the free, and much more ſcanty in the cloſe manner of making charcoal, there are very ſtrong grounds for ſuppoſing potaſh and ſoda to be formed during the proceſs.

Charcoal, properly prepared, has long been conſidered as carbon, almoſt in a ſtate of purity; and, on this ſuppoſition, the illuſtrious Lavoiſier concluded from his experiments, that carbonic acid conſiſted of 28 parts of carbon, combined

bined with 72 parts of oxygen. But, from more recent experiments by Morveau, it appears, that acid has only 17.88 parts of pure carbon, with 82.12 parts of oxygen, or nearly 18 and 82.

By the laſt, and moſt exact, experiments, it appears, that diamond is carbon in perfect purity; and, that the beſt-made charcoal, independent of its minute earthy and ſaline mixture, is a true oxyd of carbon: Hence the calculations of Lavoiſier, reſpecting the ultimate elements of ſeveral ſubſtances, in which carbon and oxygen are principal ingredients, require correction.

19. *Bitumen.* Although naturally of mineral origin, bitumen ſeems to have been produced by chemical changes from organic materials; but whether of vegetable or animal bodies, has not been ſatisfactorily determined. Bitumens are found exuding from fiſſures of ſtrata or veins, or floating on the waters of ſprings, or forming ſtrata in the earth, combined with other matters. The principal ſubſtances uſually ranked under the general denomination of bitumens, are Naphtha, Petroleum, Aſphaltum, Amber, Coal, Jet, and Melilite. But the chemical analyſis of theſe bodies, by no means warrants their being arranged together.

Naphtha is a very light pellucid or yellowiſh liquid, highly volatile and inflammable, with a very penetrating odour. It diſſolves oils, reſins, and

and caoutchouc, and is inſoluble in water or alcohol, or very ſlightly ſo. It ſeems to have conſiderable analogy with ether, and probably conſiſts of carbon, hydrogen, and oxygen.

Petroleum is ſimilar in many reſpects to naphtha, but thicker, leſs volatile and inflammable, of a brown or black colour, and affords naphtha by diſtillation.

Aſphaltum is ſolid and brittle, of a brown or black colour, melts by conſiderable heat, and is inflammable. By deſtructive diſtillation, it gives over empyreumatic oil, carbonic acid, and hydro-carbonic gas; conſequently is compoſed of carbon, hydrogen, and oxygen.

Coal differs from the former in leaving a reſiduum, leſs or more in the different varieties, of earthy matters, chiefly argil, with ſome oxyd of iron. By deſtructive diſtillation, it gives over empyreumatic oil, carbonic acid, hydro-carbonic gas, and ammonia. In cloſe veſſels, the reſiduum contains a conſiderable quantity of carbonaceous matter, which burns to white or coloured aſhes in the open fire, according to the proportion and ſtate of oxyd of iron in its compoſition. It likewiſe ſometimes gives over ſulphurous acid, probably from containing pyrites, or ſulphurat of iron. Its ultimate elements are, carbon in large quantities, hydrogen, azot, and oxygen, with an earthy baſis of argil, and ſometimes ſome magneſia.

Jet

Jet ſeems intermediate between coal and aſphaltum, as it leaves very little aſhes on incineration.

Amber has been already noticed, 10. in this ſection.

Melilite, or Honey-ſtone, is found in ſtrata of wood, mineralized by bitumen: it has a light yellow colour, and is generally cryſtallized. It is not ſoluble in alcohol or oils, and is difficultly inflammable. It ſeems to conſiſt of argil, combined with a peculiar acid, analogous to the oxalic; and is therefore a neutral ſalt.

Beſides theſe enumerated proximate elements of vegetable ſubſtances, they afford various earths and neutral ſalts, and even minute metalline portions, in their reſidua; the conſideration of which would lead far beyond our preſent limits. Certain vegetables, eſpecially of the Cruciform natural order, contain ammonia, and even ſome afford minute portions of ſulphur and phoſphorus. From all vegetables, potaſh, and from many, eſpecially marine plants, ſoda, is procurable by incineration. But, whether theſe alkalies exiſted previouſly in the plant, or are formed by change of ultimate elements during the incineration, is not decided: the latter is the moſt probable.

§ II.

§ II. *Proximate Elements of Animal Subſtances.*

This ſubject, like the analyſis of vegetable ſubſtances, would require more extended inveſtigation than our limits can admit; and, therefore, muſt be treated of only very curſorily. Animal ſubſtances differ from vegetable, in a greater tendency to putrefaction, and being hardly, or very little, liable to vinous or aceſcent fermentation. Their ultimate elements are more numerous in general than thoſe of vegetable ſubſtances; as, beſides carbon and hydrogen, they moſtly contain azot and phoſphorus: they likewiſe ſeem to have leſs oxygen in their compoſition, as they afford leſs acid on decompoſition.

§ 1. *Blood.*

1. The *Blood*, of what are called the perfect animals, is a viſcid liquid, of a red colour, with a ſweetiſh taſte, and peculiar odour. In the veins it is dark coloured, becoming florid in the lungs and in the arterial ſyſtem. The air, eſpecially oxygen gas, renders it florid; but moſt of the other gaſes make it darker. By ſpontaneous coagulation, it ſeparates into ſerum and craſſamentum.

2. *Serum* is ſlightly viſcid, yellowiſh, has a ſaline taſte, and is miſcible with water. At about 165° of Fahrenheit it coagulates, from which a ſomewhat turbid liquid may be expreſſed, which fixes when cold into a jelly. The remaining liquid is water, containing ſoda, muriat of ſoda, and a ſalt having phoſphoric acid. Thus ſerum conſiſts of albumen, or the part coagulable by heat, gelatin, or the jelly-like ſubſtance expreſſible from it, and ſaline matters, all diſſolved in water. Serum is coagulated by alcohol, acids, acidulous ſalts, and ſeveral metallic oxyds.

3. *Albumen* is coagulable by heat, unleſs diſſolved in eight or ten times its weight of water; but is not ſoluble after coagulation. It diſſolves readily in ſolutions of potaſh and ſoda, giving out ammonia; and diſſolves ſlowly in ammonia. By the nitric acid it is decompoſed; nitrous gas is diſengaged, and an oily ſubſtance, ſoluble in alcohol, remains. In cloſe veſſels, it gives out empyreumatic oil, carbonat of ammonia, carbonated and ſulphurated hydrogen gas, and pruſſic acid; the carbonaceous reſiduum containing phoſphats and carbonats of ſoda and lime, and muriat of ſoda. Hence its ultimate elements are, carbon, hydrogen, azot, phoſphorus, ſulphur, lime, ſoda, muriatic acid or its baſis, and oxygen.

4. *Gelatin*

4. *Gelatin* is ſoluble in water, and is precipitated by alcohol and the mineral acids. With tanin it forms an inſoluble compound already mentioned. Its aqueous ſolution, evaporated to dryneſs, is glue. Decompoſed by nitric acid, a large quantity of gas diſengages, and oxalic acid is formed. In cloſe veſſels, it gives over carbonic acid, hydro-carbonic gas, carbonat of ammonia, and empyreumatic oil; its carbonaceous reſiduum containing phoſphat of lime. Hence gelatin is not nearly ſo much compounded as albumen, having only carbon, hydrogen, azot, phoſphorus, lime and oxygen as its ultimate elements.

5. The *Craſſamentum,* or ſpontaneouſly coagulable part of the blood, does not readily putrefy on expoſure to air, and may be dried by moderate heat. By repeated waſhing with cold water, craſſamentum is reſolvable into its red colouring matter, which is ſoluble, and a ſolid white inſipid and inodorous elaſtic fibrous maſs, inſoluble in water except by long boiling, called gluten, coagulable lymph, or fibrin.

6. *Fibrin* is decompoſed by potaſh and ſoda, giving out ammonia, and carbonaceous matter is precipitated. It likewiſe diſſolves in acids, but when precipitated from this ſolution by alkalies, it has loſt its peculiar qualities and appearance. Nitric acid diluted diſengages from it a large quantity of azot, and oxalic acid is

formed,

formed, with ſmall portions of malic and acetous acids. By deſtructive diſtillation, it affords empyreumatic oil, carbonat of ammonia, ſome very fetid gas, probably conſiſting of hydrogen and azot with phoſphorus: the carbonaceous reſiduum contains phoſphat of lime. Its ultimate elements, therefore, ſeem the ſame with thoſe of gelatin.

7. *Colouring matter*, or the red globules of the blood, which is ſoluble in water, but ſuffers a gradual decompoſition, is changed in its colour by the gaſes in the ſame manner with blood itſelf; hence the change of the blood, from venous to arterial in the lungs, is produced by the action of oxygen. By deſtructive diſtillation, it affords empyreumatic oil, carbonated and ſulphurated hydrogen gaſes, and pruſſiat of ammonia: the carbonaceous reſiduum contains carbonat, phoſphat and muriat of ſoda, carbonat and phoſphat of lime, oxyd of iron and charcoal.

We have ſeen, by the preceding ſhort abſtract of the chemical compoſition of the various parts of the blood, that it is an extremely compound liquid, containing carbon, hydrogen, azot, phoſphorus, lime, ſoda, iron, muriatic acid, or its baſis;

ſis and oxygen. From the blood, all the other liquids of the animal body, and its ſolid parts, are formed, renewed, and augmented. All theſe ultimate elements muſt either be derived from nutrition, reſ iration, or abſorption: And although vegetable ſubſtances do not afford all of theſe ultimate elements, at leaſt in any quantity proportional to thoſe in animal ſubſtances, yet as all ingeſta, or nutritious matter, is ultimately reſolvable into the vegetable kingdom, water and atmoſpheric air, theſe muſt all be derived from thoſe ſources. It is, however, incompatible with our limits to enlarge on the ſubject of nutrition, reſpiration, and ſecretion, which would require a large volume for their proper inveſtigation.

The chief ſource of the blood is from the chyle, or nutritious materials of food, diſſolved and mixed with ſaliva, the gaſtric and pancreatic juices, and bile. It appears, that during circulation, the arterial blood loſes azot and oxygen, the venous blood having leſs of theſe, and more carbon, than the arterial. In the lungs, the venous blood is reſtored to its arterial or florid ſtate, and carbonic acid is evolved, by its ſuperabundant carbon combining with the oxygen of the reſpired air. It is highly probable, likewiſe, that the blood abſorbs azot during reſpiration, and likewiſe oxygen. During theſe changes, there is the higheſt probability that

caloric, formerly exifting combined with the refpired air, is fet free to produce temperature, and that, in this manner, refpiration acts as one fource at leaft of animal heat. What renders this idea highly probable, is, that we uniformly find animals which either do not refpire air, or which refpire it lefs regularly than the more perfect animals much colder in their temperature, and that every circumftance which accelerates the paffage of the blood through the lungs, and confequently quickens and augments refpiration, increafes animal heat. The animal fyftem likewife poffeffes the power of refifting the accumulation or too great increafe of temperature; one principal fource of which is probably from the evaporation of perfpirable matter.

§ 2. *Animal Fluids.*

Thefe are all or chiefly formed or feparated from the blood by fecretion. The principal fecreted fluids are, Milk, Lymph, Mucus, Saliva, Gaftric juice, Bile, Urine, and Perfpirable Matter.

1. *Milk* is white, fweet, and having a peculiar flavour, and differs confiderably as obtained from different animals, and even from the fame animal on different kinds of food. It naturally feparates, by ftanding, into cream, and more watery milk. Cream by agitation, during which it

it abſorbs oxygen, is converted into butter, and a thick fluid. When milk is kept ſome time after the cream ſeparates, it grows firſt acidulous, and then coagulates. If this coagulum be preſſed, a dry ſubſtance, inſoluble in water, and elaſtic, called *cheeſe*, is procured; the liquor which drains off is whey. This coagulation may be produced by various other means, ſuch as alcohol and the acids, and principally, for economical purpoſes, by the gaſtric liquor of young animals, mixed with muriat of ſoda, and diſſolved in water.

2. *Cheeſe*, or the caſeous matter of milk, when containing little or no butter, is at firſt white and opake, but grows afterwards ſomewhat tranſparent and elaſtic. It is inſoluble in cold water. It diſſolves in potaſh and ſoda, giving out ammonia; and diſſolves partially in dilute mineral acids. In a moiſt atmoſphere, it ſoon grows putrid. By deſtructive diſtillation, it gives over empyreumatic oil, ammonia, and hydro-carbonic gas, leaving a carbonaceous reſiduum, which contains potaſh or ſoda.

3. *Whey* or *ſerum*, when perfectly free from cream or butter, is yellowiſh, and has a bland, ſaline, ſweetiſh taſte. By evaporation, it affords a ſaline ſubſtance; which, by a ſecond ſolution and evaporation, becomes a white, ſweetiſh, cryſtallized ſalt, called *ſugar of milk*. Treated with nitric acid, nitrous gas is diſengaged, li-

quid oxalic acid, and concrete ſaccho-lactic acids, are produced.

From the quantity of ſaccharine ſubſtance in whey, it is ſuſceptible of vinous and aceſcent fermentation: But the acid is not vinegar; it is a peculiar acid, called the *lactic*.

Whey likewiſe contains muriats of lime, potaſh, and ſoda, and ſome ſalt which contains phoſphoric acid. Hence, though milk has many properties reſembling vegetable ſubſtances, its chemical analyſis ſhews, that its compoſition is more analogous to animal matter.

4. *Lymph*, which is contained in the lymphatic or abſorbent veſſels, is a viſcid, pellucid, and inſipid liquid, apparently a ſolution of the albumen and gelatin of the blood, like which, it is coagulable by heat, acids, and alcohol.

5. *Mucus*, or the thickiſh liquid which ſpreads over the paſſages and internal ſurfaces of the animal body, is probably lymph more inſpiſſated.

6. *Saliva* is imperfectly ſoluble in water, and is coagulable by the mineral acids. Diſſolved in alkalies, it gives out ammonia. It ſeems to be a ſolution of albumen in water, with the addition of ſome muriat of ſoda, and perhaps ſome phoſphat of lime.

7. *Gaſtric Liquor*, which is ſecreted from the inner coat of the ſtomach, and probably from at leaſt part of the inteſtines, is ſoluble in water

has a ſlight ſaline taſte, and is quite limpid. Its peculiar property is that of diſſolving the food in the ſtomach, into a milky liquid called *chyle*. After death this ſolvent power even acts on the ſtomach itſelf. By evaporation it is reduced to a dry maſs, which gives out in deſtructive diſtillation ammonia and empyreumatic oil, leaving carbonaceous matter, which contains muriat of ſoda and other neutral ſalts.

8. *Bile* is a thick yellowiſh-green liquid, having an intenſely bitter taſte, and faint odour. It is ſoluble in water; and by alcohol, albumen is coagulated from it. The green bitter ſubſtance remains diſſolved in the alcohol, and is of a reſinous nature. It may be ſeparated by evaporating the alcohol, or precipitated from it by water. When concrete, this reſin of the bile is inflammable, and fuſes at 120° of Fahrenheit. By oxymuriatic acid, it changes to a white, unctuous, bitter concrete, which is ſoluble in alcohol, and in hot water. By deſtructive diſtillation, bile gives out empyreumatic oil, carbonat of ammonia, pruſſic, and carbonic acids, and hydro-carbonic gas: its ultimate elements therefore are, carbon, hydrogen, azot, phoſphorus, and oxygen.

Calculous concretions, named *gall-ſtones*, are often formed in the gall-bladder, of various degrees of colour and hardneſs; often conſiſting of ſeparate cryſtalline concentric laminæ, of an

unctuous appearance, and inflammable. Some are ſoluble in alcohol and eſſential oils. By chemical analyſis, they afford reſin of bile, benzoic acid, and ſmall quantities of lime, ſoda, and neutral ſalts, having a baſis of ammonia.

9. *Urine*, when firſt diſcharged, is ſlightly acid, but ſoon evolves ammonia, and becomes alkaline and putrid. Evaporated, it gives out water and carbonat of ammonia, leaving a thick, brown, fetid maſs, from which deſtructive diſtillation affords a very fetid empyreumatic oil, carbonat of ammonia, ſeveral compound gaſes, and a ſmall portion of phoſphorus. Alkalies precipitate phoſphat of lime from urine. Tanin precipitates a quantity of gelatin. The ſaline parts of urine, part of which cryſtallizes on cooling, are principally phoſphats of ſoda, ammonia, lime, and magneſia, muriats of ſoda and ammonia, lithic or uric acid, and ſometimes, eſpecially in graminivorous animals and the urine of children, benzoic acid.

By peculiar proceſſes, a large quantity of a peculiar ſubſtance, called *uree*, is procurable from urine, on which the colour, taſte, and properties of freſh urine principally depend. It conſtitutes about a twentieth part of the urine, is ſoluble in water, and readily decompoſes ſpontaneouſly, affording carbonat of ammonia. By deſtructive diſtillation, it gives out a large quantity of carbonat of ammonia, and a ſmall portion of empyreumatic oil.

Calculous

Calculous concretions frequently form in the bladder and kidneys. Thefe chiefly confift of lithic acid, and animal matter, probably albumen, with very little lime, often not more than a two-hundredth part, fometimes a great deal more. Some confift of phofphoric acid combined with magnefia and ammonia; and in fome oxalat of lime has been detected.

10. *Perfpirable Matter*, or the conftant exhalation from the furface of the body of animals, confifts partly of a fmall portion of carbonic acid gas, and partly of water, holding lymph and fome faline matters in folution.

§ 3. *Animal Solids.*

1. *Membrane*, which is the bafis of cellular fubftance, ligaments, tendons, cartilage, and fkin, is chiefly compofed of gelatin or animal glue, to which they may almoft entirely be refolved by long boiling in water, and fome of thefe contain lefs or more of phofphat of lime.

2. *Bone* confifts chiefly of gelatin, united with phofphat of lime. By deftructive diftillation, bone affords carbonat of ammonia, fetid empyreumatic oil, and hydro-carbonic gas, leaving a large carbonaceous refiduum, containing moftly phofphat of lime, with fmaller portions of carbonat and fulphat of lime. *Horn* is fimilar in pro-

perties and compofition to bone. *Shells* contain a much larger quantity of carbonat of lime, and fome confift of hardly any thing elfe, with a fmall portion of gelatin.

3. *Mufcular fibre*, by careful wafhing, becomes white, infipid, and elaftic, and feems to confift chiefly of fibrin. With nitric acid, it gives out azotic gas, and is converted into oxalic and malic acids. Decompofed by heat, befides the ufual animal products, zoonic acid is obtained. The water in which mufcular fibre has been macerated, contains the colouring matter of blood, gelatin, albumen, a fmall portion of faline matter, and fat.

4. *Fat* is of various confiftence, from different animals; it is white, infipid, and inodorous, infoluble in water or alcohol, combines with alkalies into foap, and is inflammable. It grows rancid by expofure to air, being oxygenated, and a peculiar acid is formed, called *febacic acid*, which may likewife be formed by means of nitric acid. By deftructive diftillation, it affords acid liquor, and empyreumatic oil, and hydro-carbonic gas, leaving a carbonaceous refiduum.

5. *The Brain* confifts moftly of albumen, with fome faline fubftances, efpecially phofphats of lime, foda, and ammonia.

CHAP.

CHAP. XII.

Of the Decompoſition of Vegetable and Animal Subſtances by the Action of Fire.

BEFORE we can thoroughly comprehend what takes place during the decompoſition of vegetable ſubſtances by fire, we muſt take into conſideration the nature of the elements which enter into their compoſition, and the different affinities which the particles of theſe elements exert upon each other, and the affinity which caloric poſſeſſes with each of them. The true conſtituent elements of vegetables are hydrogen, oxygen, and carbon: Theſe are common to all vegetables, and no vegetable can exiſt without them. Such other ſubſtances as exiſt in particular vegetables are only eſſential to the compoſition of thoſe in which they are found, and do not belong to vegetables in general.

Of theſe elements, hydrogen and oxygen have a ſtrong tendency to unite with caloric, and be converted into gas, while carbon is a fixed element, having little affinity with caloric. On the other hand, oxygen, which, in the uſual temperature, tends almoſt equally to unite with

with hydrogen or with carbon, has a much ſtronger affinity with carbon, when at the red heat *, and then unites with it to form carbonic acid.

Although we are far from being able to appreciate all theſe powers of affinity, or to expreſs their proportional energy by numbers, we are certain, that, however variable they may be, when conſidered in relation to the quantity of caloric with which they are combined, they are all nearly in equilibrium in the uſual temperature of the atmoſphere; hence vegetables neither contain oil †, water, nor carbonic acid, though they contain all the elements of theſe ſubſtances. The hydrogen is not combined particularly with the oxygen nor with the carbon;

* Though this term, red heat, does not indicate any abſolutely determinate degree of temperature, I ſhall uſe it ſometimes to expreſs a temperature, conſiderably above that of boiling water.—A.

† I muſt be underſtood here to ſpeak of vegetables reduced to a perfectly dry ſtate; and, with reſpect to oil, I do not mean that which is procured by expreſſion either in the cold, or in a temperature not exceeding that of boiling water; I only allude to the empyreumatic oil procured by diſtillation with a naked fire, in heat ſuperior to the temperature of boiling water, which is the only oil declared to be produced by the operation of fire. What I have publiſhed upon this ſubject in the Memoirs of the Academy for 1786 may be conſulted.—A.

bon; and reciprocally: The particles of these three substances form a triple combination, which remains in equilibrium, while undisturbed by caloric; but a very slight increase of temperature is sufficient to overturn this structure of combination.

If the increased temperature to which the vegetable is exposed does not exceed the heat of boiling water, one part of the hydrogen combines with the oxygen, and forms water; the rest of the hydrogen combines with a part of the carbon, and forms volatile oil; while the remainder of the carbon, being set free from its combination with the other elements *, remains fixed in the bottom of the distilling vessel.

When, on the contrary, we employ a red heat, no water is formed, or, at least, any that may have been produced, by the first application of the heat, is decomposed: the oxygen, having a greater affinity with the carbon at this degree of heat, combines with it to form carbonic acid; and the hydrogen, being left free from combination with the other elements, unites

* This statement is only partially true, for a small part of the ingredients remains very obstinately attached to the carbon, and can hardly be driven from it without the assistance of oxygen, by means of which the carbon itself suffers combustion.—T.

unites with caloric, and escapes in the state of hydrogen gas *. In this high temperature, either no oil is formed, or if any has been produced during the lower temperature, at the beginning of the experiment, it is decomposed by the action of the red heat. Thus the decomposition of vegetable matter, under a high temperature, is produced by the action of double and triple affinities; while the carbon attracts the oxygen on purpose to form carbonic acid, the caloric attracts the hydrogen, and converts it into hydrogen gas.

The distillation of every species of vegetable substance confirms the truth of this theory, if we can give that name to a simple relation of facts. When sugar is submitted to distillation, so long as we only employ a heat but a little below that of boiling water, it only loses its water of crystallization; it still remains sugar, and retains all its properties; but, immediately upon raising the heat only a little above that degree, it becomes blackened, a part of the carbon separates from the combination, water slightly acidulated passes over, accompanied by a

* The hydrogen gas, produced in this way, is not pure, but holds a considerable portion of carbon in solution: It is carbonated hydrogen gas, called, in the old chemical language, Heavy inflammable air.—T.

a little oil, and the charcoal * which remains in the retort, is nearly a third part of the original weight of the ſugar.

The operation of affinities which takes place, during the decompoſition, by fire, of vegetables which contain azot, ſuch as the cruciferous plants, and of thoſe containing phoſphorus, is more complicated; but, as theſe ſubſtances only enter into the compoſition of vegetables in very ſmall quantities, they only, apparently, produce ſlight changes upon the products of diſtillation. The phoſphorus ſeems to combine with carbon, and, acquiring fixity from that union, remains behind in the retort; while the azot, combining with a part of the hydrogen, forms ammoniac † or volatile alkali.

Animal ſubſtances, being compoſed nearly of the ſame elements with cruciferous plants, give

* The term charcoal is here retained, becauſe it is ſtill contaminated with ſeveral foreign matters. Carbon ſtrictly ſpeaking, is only uſed to denominate the pure elementary and combuſtible part of charcoal, which part acts alone in combinations and decompoſitions.—T.

† Dr Blacks propoſed term *ammona*, as will be more particularly noticed in the ſequel, ſeems better adapted as a ſingle term for this ſubſtance than the one here uſed. Beſides, in the above explanation, the ammoniac or ammona, whichever term be preferred, is not pure, being combined with carbonic acid, wherefore it ought to have been named Carbonated ammoniac.—T.

give almoſt the ſame products in diſtillation; with this difference, that, as they contain a greater quantity of hydrogen and azot, they produce more oil and more ammoniac. I ſhall only produce one fact as a proof of the exactneſs with which this theory explains all the phenomena that occur during the diſtillation of animal ſubſtances; which is the rectification, and total decompoſition, of volatile animal oil, commonly known by the name of Dippels oil. When theſe oils are procured by a firſt diſtillation in a naked fire they are brown, from containing a little carbon, almoſt in a free ſtate; but they become quite colourleſs by rectiſication: Even in this ſtate, the carbon in their compoſition has ſo ſlight a connection with the other elements as to ſeparate from them by mere expoſure to the air. If we put a quantity of this animal oil, well rectified, and conſequently clear, limpid, and tranſparent, into a bell-glaſs filled with oxygen gas over mercury, in a ſhort time the gas is much diminiſhed, being abſorbed by the oil; the oxygen combining with the hydrogen of the oil forms water, which ſinks to the bottom; at the ſame time the carbon, which was combined with the hydrogen, being ſet free, manifeſts itſelf by rendering the oil black. Hence the only way of preſerving theſe oils colourleſs and tranſparent, is by keeping them in bottles perfectly full and accurately

ly corked, to hinder the contact of air, which always difcolours them.

Succeffive rectifications of this oil furnifh another phenomenon confirming our theory. In each diftillation a fmall quantity of charcoal remains in the retort; and a little water is formed, by the union of the oxygen contained in the air of the diftilling veffels with the hydrogen of the oil. As this takes place in each fucceffive diftillation, if we make ufe of large veffels and a confiderable degree of heat, we at laft decompofe the whole of the oil, and change it entirely into water and charcoal. When we ufe fmall veffels, and efpecially when we employ a flow fire, or a degree of heat only a little above that of boiling water, the total decompofition of thefe oils, by repeated diftillation, is greatly more tedious, and more difficultly accomplifhed. I fhall give a particular detail to the Academy, in a feparate memoir, of all my experiments upon the decompofition of oil; but what I have related above may fuffice to give juft general ideas of the compofition of animal and vegetable fubftances, and of their decompofition by the action of fire.

CHAP.

CHAP. XIII.

Of the Decompoſition of Vegetable Oxyds by the Vinous Fermentation.

THE manner in which wine, cyder, mead, and all the liquors formed by the ſpiritous fermentation, are produced, is well known to every one. The juice of grapes or of apples being expreſſed, and the latter being diluted with water, they are put into large vats, which are kept in a temperature of at leaſt 54.5° of the thermometer. A rapid inteſtine motion, or fermentation, very ſoon takes place; numerous globules form in the liquid, and burſt at the ſurface; when the fermentation is at its height, the quantity of gas diſengaged is ſo great as to make the liquor appear as if boiling violently over a fire. When this gas is carefully gathered, it is found to be carbonic acid perfectly pure *, and free from admixture with any other ſpecies of air or gas.

When

* This aſſertion of the perfect purity of carbonic acid gas diſengaged during the vinous fermentation, muſt be taken with ſome allowance; for it almoſt always, I believe conſtantly,

When the fermentation is completed, the juice of grapes is changed, from being ſweet and full of ſugar, into a vinous liquor, which no longer contains any ſugar, and from which we procure by diſtillation an inflammable liquor, known in commerce under the name of Spirit of Wine. As this liquor is produced by the fermentation of any ſaccharine matter whatever diluted with water, it muſt have been contrary to the principles of our nomenclature to call it ſpirit of wine rather than ſpirit of cyder, or of fermented ſugar; wherefore we have adopted a more general term, and the Arabic word *alcohol* ſeems extremely proper for the purpoſe.

This operation is one of the moſt extraordinary in chemiſtry. We muſt examine whence proceed the diſengaged carbonic acid and the inflammable liquor produced, and in what manner a ſweet vegetable oxyd becomes thus converted into two ſuch oppoſite ſubſtances, whereof one is combuſtible, and the other eminently the contrary. To ſolve theſe two queſtions, it is neceſſary to be previouſly acquainted with the analyſis of the fermentable ſubſtance, and of the products of the fermentation.

conſtantly, contains ſome alcohol, beſides a conſiderable quantity of aqueous gas or water, in ſolution. The latter does not affect its purity; the former does ſo in ſome degree.—T.

We may lay it down as an inconteſtible axiom, that, in all the operations of art and nature, nothing is created; an equal quantity of matter exiſts both before and after the experiment; the quality and quantity of the elements remain preciſely the ſame: and nothing takes place beyond changes and modifications in the combinations of theſe elements. Upon this principle, the whole art of performing chemical experiments depends: We muſt always ſuppoſe an exact quality between the elements of the body examined, and thoſe of the products of its analyſis.

Hence, ſince from muſt of grapes we procure alcohol and carbonic acid, I have undoubted right to ſuppoſe that muſt conſiſts of carbonic acid and of alcohol *. From theſe premiſes, we have two methods of aſcertaining what paſſes during vinous fermentation: Either by determining the nature of, and the elements which compoſe, the fermentable ſubſtances; or by accurately examining the products reſulting from fermentation; and it is evident that the knowledge

* In this aſſertion the conſequences do not ſtrictly follow from the premiſes; becauſe from the muſt of grapes we procure carbonic acid and alcohol, it is a neceſſary conſequence that the original muſt contains the conſtituent elements of carbonic acid and of alcohol, but not that theſe products of fermentation are already formed.—T

ledge of either of theſe muſt lead to accurate concluſions concerning the nature and compoſition of the other. From theſe conſiderations, it became neceſſary accurately to determine the conſtituent elements of the fermentable ſubſtances; and, for this purpoſe, I did not make uſe of the compound juices of fruits, the rigorous analyſis of which is perhaps impoſſible, but made choice of ſugar, which is eaſily analyzed, and the nature of which I have already explained. This ſubſtance is a true vegetable oxyd with two baſes, compoſed of hydrogen and carbon, brought to the ſtate of an oxyd, by means of a certain proportion of oxygen; and theſe three elements are combined in ſuch a way, that a very ſlight force is ſufficient to deſtroy the equilibrium of their connection. By a long train of experiments, made in various ways, and often repeated, I aſcertained that the proportion in which theſe ingredients exiſt in ſugar, are nearly 8 parts of hydrogen, 64 parts of oxygen, and 28 parts of carbon, all by weight, forming 100 parts of ſugar.

Sugar muſt be mixed with about four times its weight of water, to render it ſuſceptible of fermentation; and even then the equilibrium of its elements would remain undiſturbed, without the aſſiſtance of ſome ſubſtance to give a commencement to the fermenta-

 tion.

tion*. This is accompliſhed by means of a little yeaſt from beer; and, when the fermentation is once excited, it continues of itſelf until completed. I ſhall, in another place, give an account of the effects of yeaſt, and other ferments, upon fermentable ſubſtances. I have uſually employed 10 *libs.* of yeaſt, in the ſtate of paſte, for each 100 *libs.* of ſugar, with as much water as is four times the weight of the ſugar. I ſhall give the reſults of my experiments exactly as they were obtained, preſerving even the fractions produced by calculation.

TABLE

* This is not ſtrictly true; for, eſpecially in warm weather, all ſyrups are apt to run into fermentation, unleſs very rich of the ſugar, and carefully preſerved. At the ſame time, this ſpontaneous fermentation is not ſo regular as when aſſiſted by yeaſt, and is apt to become in part acetous, before completing the vinous proceſs.—T.

TABLE I. *Materials of Fermentation* *.

			libs.
Water		– – –	400.
Sugar		– – –	100.
Yeast, in paste, 10 *libs.* composed of	Water	–	7.2391493
	Dry Yeast	–	2.7608507
		Total,	510 *libs.*

TABLE II. *Constituent Elements of the Materials of Fermentation.*

		libs.
407.2391493 *libs.* of water, composed of	Hydrogen	61.0858724
	Oxygen	346.1532769
100 *libs.* sugar, composed of	Hydrogen	8.
	Oxygen	64.
	Carbon	28.
2.7608507 *libs.* of dry yeast, composed of	Hydrogen	.2900716
	Oxygen	1.6437457
	Carbon	.7876519
	Azot	.0393815
	Total weight	510. *libs.*

* The quantities in the original are expressed in the common divisions of the Paris pound, but, to render the results more generally useful to the English reader, they are all here reduced to decimals, which answer equally for any pound.—T.

TABLE III. *Recapitulation of these Elements.*

		libs.	libs.
Oxygen	of the water	340.	411.7970226
	of the water in the yeast	6.1532769	
	of the sugar	64.	
	of the dry yeast	1.6437457	
Hydrogen	of the water	60.	69.3759440
	of the water in the yeast	1.0858724	
	of the sugar	8.	
	of the dry yeast	0.2900716	
Carbon.	of the sugar	28.	28.7876519
	of the yeast	0.7876519	
Azot of the yeast			0.0393815
		In all	510. *libs.*

Having thus accurately determined the nature and quantity of the constituent elements of the materials submitted to fermentation, we have next to examine the products resulting from that process. For this purpose, I placed the above 510. *libs.* of fermentable liquor in a proper * apparatus, by means of which I could accurately determine the quantity and quality of gas disengaged during the fermentation, and could

* The above apparatus is described in the Third Part. —A.

could even weigh every one of the products feparately, at any period of the procefs I judged proper.

An hour or two after the fubftances are mixed together, efpecially if they are kept in a temperature of from 66° to 73° of the thermometer, the firft marks of fermentation commence; the liquor turns thick and frothy, little globules of air are difengaged, which rife and burft at the furface; the quantity of thefe globules quickly increafes, and there is a rapid and abundant production of very pure carbonic acid, accompanied with a fcum, which is the yeaft feparating from the mixture. After fome days, lefs or more, according to the degree of heat, the inteftine motion and difengagement of gas diminifh; but thefe do not ceafe entirely, nor is the fermentation completed for a confiderable time. During the procefs, 35.3458116 *libs.* of dry carbonic acid are difengaged, which carry along with them 13.9140625 *libs.* of water. There remains in the veffel 460.7401259 *libs.* of vinous liquor, flightly acidulous. This is at firft muddy, but clears of itfelf, and depofites a portion of yeaft. When we feparately analyze all thefe fubftances, which is effected by very troublefome proceffes, we have the refults as given in the following Tables. This procefs, with all the fubordinate calculations and analyzes, will be detailed at large in the Memoirs of the Academy.

TABLE IV. *Products of Fermentation.*

		libs.
35.3458116 *libs.* of carbonic acid, composed of	Oxygen -	25.4490017
	Carbon -	9.8968099
408.9780816 *libs.* of water, composed of	Oxygen -	347.6314019
	Hydrogen -	61.3466797
57.7016059 *libs.* of dry alcohol, composed of	Oxygen, combined with hydrogen	31.3897570
	Hydrogen, combined with oxygen	5.5393880
	Hydrogen, combined with carbon	4.0390625
	Carbon, combined with hydrogen	16.7333984
2.5000000 *libs.* of dry acetous acid, composed of	Hydrogen -	0.1562500
	Oxygen -	1.7187500
	Carbon -	0.6250000
4.0940755 *libs.* of residuum of sugar, composed of	Hydrogen -	0.3275825
	Oxygen -	2.6201172
	Carbon -	1.1463758
1.3804254 *libs.* of dry yeast, composed of	Hydrogen -	0.1450738
	Oxygen -	0.8218317
	Carbon -	0.3938802
	Azot -	0.0196397
510 *libs.*		510 *libs.*

TABLE

TABLE V. *Recapitulation of the Products.*

		libs.
409.6308595 *libs.* of oxygen contained in the	Water –	347.6314019
	Carbonic acid –	25.4490017
	Alcohol –	31.3897570
	Acetous acid –	1.7187500
	Refiduum of fugar	2.6201172
	Yeaft – –	0.8218317
28.7954643 *libs.* of carbon contained in the	Carbonic acid –	9.8968099
	Alcohol –	16.7333984
	Acetous acid –	0.6250000
	Refiduum of fugar	1.1463758
	Yeaft – –	0.3938802
71.5540365 *libs.* of hydrogen contained in the	Water – –	61.3466797
	Water of the alcohol – –	5.5398880
	Combined with the carbon of the alcohol –	4.0390625
	Acetous acid –	0.1562500
	Refiduum of fugar	0.3275825
	Yeaft – –	0.1450738
0.0196397 *libs.* of azot in the yeaft	–	0.0196397
510 *libs.*		510 *libs.*

In the calculation of thefe refults, I have been exact even to minutenefs: Not that it is poffible, in experiments of this nature, to carry our accuracy fo far; but as the experiments were made only with a few pounds of fugar, and as, for the fake of comparifon, I reduced the refults of the real experiments to the quintal, or

or imaginary hundred pounds, I thought it neceſſary to leave the fractional parts preciſely as produced by calculation.

When we conſider the reſults preſented by theſe tables with attention, it is eaſy to diſcover exactly what occurs during fermentation. In the firſt place, out of the 100 *libs.* of ſugar employed, 4.0940755 *libs.* remain, without having ſuffered decompoſition: ſo that, in reality, we have only operated upon 95.9059245 *libs.* of ſugar; that is to ſay, upon 61.37979168 *libs.* of oxygen, 7.67247396 *libs.* of hydrogen, and 26.85365886 *libs.* of carbon. By comparing theſe quantities, we find that they are fully ſufficient for forming the whole of the alcohol, carbonic acid, and acetous acid, produced by the fermentation. It is not, therefore, neceſſary to ſuppoſe that any water has been decompoſed during the experiment, unleſs it be pretended that the oxygen and hydrogen exiſt in the ſugar already combined in that form. On the contrary, I have already made it evident that hydrogen, oxygen, and carbon, the three conſtituent elements of vegetable ſubſtances, remain in a ſtate of equilibrium, or mutual union with each other, which ſubſiſts ſo long as this union remains undiſturbed by increaſed temperature, or by means of ſome new compound attraction; and that then only theſe elements combine,

two

two and two together, to form water and carbonic acid.

The effects of the vinous fermentation upon ſugar is thus reduced to the mere ſeparation of its elements into two portions; one part is oxygenated at the expence of the other, ſo as to form carbonic acid, while the other part, being diſoxygenated in favour of the former, is converted into the combuſtible ſubſtance called alcohol; therefore, if it were poſſible to re-unite alcohol and carbonic acid together, we ought to form ſugar. It is evident that the carbon and hydrogen in the alcohol do not exiſt in the ſtate of oil, but that they are combined with a portion of oxygen, which renders them miſcible with water; wherefore theſe three ſubſtances, oxygen, hydrogen, and carbon, exiſt here likewiſe in a ſpecies of equilibrium, or reciprocal combination; and, in fact, when they are made to paſs through a red-hot tube of glaſs or porcelain, this union or equilibrium is deſtroyed; theſe elements become recombined two and two, and water and carbonic acid are formed.

I had formerly advanced, in my firſt Memoirs upon the formation of water, that it was decompoſed in a great number of chemical experiments, and particularly during the vinous fermentation. I then ſuppoſed that water exiſted ready formed in ſugar, though I am now convinced that ſugar only contains the elements

proper

proper for compoſing it. It may be readily conceived, that it muſt have coſt me a good deal to abandon my firſt notions; but by ſeveral years reflection, and after a great number of experiments and obſervations upon vegetable ſubſtances, I have fixed my ideas as above.

I ſhall finiſh what I have to ſay upon vinous fermentation, by obſerving, that it furniſhes us with the means of analyzing ſugar and every vegetable fermentable matter. We may conſider the ſubſtances ſubmitted to fermentation, and the products reſulting from that operation, as forming an algebraic equation; and, by ſucceſſively ſuppoſing each of the elements in this equation unknown, we can calculate their values in ſucceſſion, and thus verify our experiments by calculations, and our calculations by experiment, reciprocally. I have often ſucceſsfully employed this method for correcting the firſt reſults of my experiments, and to direct me in the proper road for repeating them to advantage. I have explained myſelf more at large upon this ſubject, in a Memoir upon vinous fermentation already preſented to the Academy, and which will ſpeedily be publiſhed.

CHAP.

CHAP. XIV.

Of the Putrefactive Fermentation.

THE phenomena of putrefaction are caufed, like thofe of vinous fermentation, by the operation of extremely complicated affinities. The conftituent elements of the bodies which are fubmitted to this procefs, ceafe to continue in equilibrium, in their original threefold combination, and form themfelves anew into binary combinations *, or compounds, confifting of two elements only; but thefe are entirely different from the refults produced by the vinous fermentation. Inftead of part of the hydrogen remaining united with part of the water and carbon to form alcohol, as in the vinous fermentation, the whole of the hydrogen is diffipated, during putrefaction, in the form of hydrogen gas; while, at the fame time, the oxygen and carbon, uniting with caloric, efcape in the form of carbonic acid; fo that, when the whole procefs is finifhed, efpecially if the materials

* Binary combinations are fuch as confift of two fimple elements combined together. Ternary, and quaternary, confift of three and of four elements.—T.

terials have been mixed with a ſufficient quantity of water, nothing remains but the earth of the vegetable, mixed with a ſmall portion of charcoal and iron. Thus, putrefaction is nothing more than a complete analyſis of vegetable ſubſtance; during which the whole of the conſtituent elements is diſengaged in form of gas, except the earth, which remains in the ſtate of mould *.

Such is the reſult of putrefaction, when the ſubſtances ſubmitted to it contain only oxygen, hydrogen, carbon, and a little earth. But this caſe is rare, and theſe ſubſtances putrefy imperfectly and with difficulty, and require a conſiderable time to complete their putrefaction. It is otherwiſe with ſubſtances containing azot, which indeed exiſts in all animal matters, and even in a conſiderable number of vegetable ſubſtances. This additional element is remarkably favourable to putrefaction; and for this reaſon, animal matter is mixed with vegetable, when the putrefaction of theſe is wiſhed to be haſtened. The whole art of forming compoſts and dunghills, for the purpoſes of agriculture, conſiſts in the proper application of this admixture.

The

* In the Third Part will be given the deſcription of an apparatus proper for being uſed in experiments of this kind.—A.

The addition of azot to the materials of putrefaction not only accelerates the process, but that element likewise combines with part of the hydrogen, and forms a new substance, called *volatile alkali*, or *ammoniac*. The results obtained by analyzing animal matters, by different processes, leave no room for doubt with regard to the constituent elements of ammoniac; for, whenever the azot has been previously separated from these substances, no ammoniac is produced, and in all cases they furnish ammoniac only in proportion to the azot they contain. This composition of ammoniac is likewise fully proved by Mr Berthollet, in the Memoirs of the Academy for 1781, p. 316. where he gives a variety of analytical processes by which ammoniac is decomposed, and its two elements, azot and hydrogen, procured separately.

I have already mentioned, in Chap. X. that almost all combustible bodies are capable of being combined with each other: Hydrogen gas possesses this quality, of combining with other combustible substances, in an eminent degree: It dissolves carbon, sulphur, and phosphorus, producing the compounds named *carbonated hydrogen gas*, *sulphurated hydrogen gas*, and *phosphorated hydrogen gas*. The two latter of these gases have a peculiarly disagreeable flavour; the sulphurated hydrogen gas has a strong resemblance to the smell of rotten eggs, and the phosphorated

phoſphorated ſmells exactly like putrid fiſh. Ammoniac has likewiſe a peculiar odour, not leſs penetrating or leſs diſagreeable than theſe other gaſes. From the mixture of theſe different flavours, proceeds the fetor which always accompanies the putrefaction of animal ſubſtances. Sometimes the ammoniac predominates, which is eaſily perceived by its ſharpneſs upon the eyes; ſometimes, as in feculent matters, the ſulphurated gas is moſt prevalent; and ſometimes, as in putrid herrings, the phoſphorated hydrogen gas is moſt abundant.

I long ſuppoſed that nothing could derange or interrupt the courſe of putrefaction; but Mr Fourcroy and Mr Thouret have obſerved ſome peculiar phenomena in dead bodies, buried at a certain depth, and preſerved to a certain degree, from contact with air; having found the muſcular fleſh frequently converted into true animal fat *. This muſt have ariſen from the diſengagement, by ſome unknown cauſe, of the azot, naturally contained in the animal ſubſtance, leaving only the hydrogen and carbon remaining, which are the elements proper for producing fat or oil. This obſervation,

* This proceſs has been lately imitated artificially; and the fatty ſubſtance, exactly ſimilar in all reſpects to ſpermaceti, can be readily made from the fleſh or muſcular parts of all animal bodies.—T.

tion, on the poſſibility of converting animal ſubſtances into fat, may ſome time or other lead to diſcoveries of great importance to ſociety. The fæces of animals, and other excrementitious matters, are chiefly compoſed of carbon and hydrogen, and approach conſiderably to the nature of oil, of which they furniſh a conſiderable quantity by diſtillation with a naked fire; but the intolerable fœtor, which accompanies all the products of theſe ſubſtances, prevents our expecting that, at leaſt for a long time, they can be rendered uſeful in any other way than as manures.

I have only given conjectural approximations in this chapter, upon the compoſition of animal ſubſtances, which is hitherto imperfectly underſtood. We know that they are compoſed of hydrogen, carbon, azot, phoſphorus, and ſulphur, all of which, in a ſtate of quintuple combination, are brought to the ſtate of oxyd by a larger or ſmaller quantity of oxygen. We are, however, ſtill unacquainted with the proportions in which theſe ſubſtances are combined, and muſt leave it to time to complete this part of chemical analyſis, as it has already done with ſeveral others.

CHAP. XV.

Of the Acetous Fermentation.

THE acetous fermentation is nothing more than the acidification or oxygenation of wine *, produced in the open air, by means of the abſorption of oxygen. The reſulting acid is the acetous acid, commonly called Vinegar, which is compoſed of hydrogen and carbon united together in proportions not yet aſcertained, and changed into the acid ſtate by oxygen. As vinegar is an acid, we might conclude from analogy, that it contains oxygen, but this is put beyond doubt by direct experiments: In the firſt place, we cannot change wine into vinegar without the contact of air containing oxygen; ſecondly, this proceſs is accompanied by a diminution of the volume of the air in which it is carried on, from the abſorption of its oxygen; and thirdly, wine may be changed into vinegar, by any other means of oxygenation.

Independent

* The word Wine, in this chapter, is uſed to ſignify the liquor produced by the vinous fermentation whatever vegetable ſubſtance may have been uſed for obtaining it.—T.

Independent of the proofs which these facts furnish of the acetous acid being produced by the oxygenation of wine, an experiment made by Mr Chaptel, Professor of Chemistry at Montpellier, gives a distinct view of what takes place in this process. He impregnated some water with about its own bulk of carbonic acid from fermenting beer, and placed this water in a cellar, in vessels communicating with the air, and in a short time the whole was converted into acetous acid. This carbonic acid gas, procured from beer vats in fermentation, is not perfectly pure, but contains a great quantity of alcohol in solution, wherefore water impregnated with it contains all the materials necessary for forming the acetous acid. The alcohol furnishes hydrogen and one portion of carbon; the carbonic acid furnishes oxygen and the rest of the carbon; and the air of the atmosphere furnishes the rest of the oxygen necessary for changing the mixture into acetous acid. From this observation it follows, that nothing but hydrogen is wanting to convert carbonic acid into acetous acid; or, more generally, that, by means of hydrogen, and according to the degree of oxygenation, carbonic acid may be changed into all the vegetable acids; and, on the contrary, that, by depriving any of the vegetable acids of their hydrogen, they may be converted into carbonic acid.

 Although

Although the principal facts relating to the acetous acid are well known, yet numerical precision is still wanting, until furnished by more exact experiments than any hitherto performed; wherefore I shall not enlarge any farther upon the subject. It is sufficiently shewn by what has been said, that the constitution of all the vegetable acids and oxyds is exactly conformable to the formation of vinegar; but farther experiments are necessary to teach us the proportion of the constituent elements in all these acids and oxyds. We may easily perceive, however, that this part of chemistry, like all the rest of its divisions, makes rapid progress towards perfection, and that it is already rendered greatly more simple than was formerly believed.

CHAP.

CHAP. XVI.

Of the Formation of Neutral Salts, and of their different Bafes.

WE have juft feen, that all the oxyds and acids from the animal and vegetable kingdoms are formed from a fmall number of fimple elements, by means of combination with oxygen, or at leaft from fuch bodies as have not hitherto been fufceptible of decompofition, and which muft therefore be confidered as fimple fubftances, in the prefent ftate of our knowledge; thefe are azot, fulphur, phofphorus, carbon, hydrogen, and the muriatic radical *. We may juftly admire the fimplicity of the means employed by nature to multiply qualities and forms, whether by combining three or four acidifiable bafes in different proportions, or by altering the

 dofe

* I have not ventured to omit this element, as here enumerated with the other principles of animal and vegetable fubftances, though it is not at all taken notice of in the preceding chapters as entering into the compofition of thefe bodies. It has been already mentioned, in a former note, that the muriatic radical is fufpected to be hydrogen.—T.

dofe of oxygen employed for oxydating or acidifying them. We fhall find the means no lefs fimple and diverfified, and as abundantly productive of forms and qualities, in the order of bodies we are now about to treat of.

Acidifiable fubftances, by combining with oxygen, and their confequent converfion into acids, acquire a great fufceptibility for farther combination; they become capable of uniting with alkaline, earthy, and metallic bodies, by which means neutral falts are formed. Acids may therefore be confidered as true *falifying* principles, and the fubftances with which they unite to form neutral falts may be called *falifiable* bafes: The nature of the union which thefe two principles form with each other is meant as the fubject of the prefent chapter.

The foregoing view of the acids prevents them from being confidered as falts, though they are poffeffed of many of the principal properties of faline bodies, as folubility in water, &c. It is already obferved, that they are the refults of a firft order of combination, being compofed of two fimple elements, or at leaft of elements which act as if they were fimple, and they may therefore be ranked, to ufe the language of Stahl, in the order of *mixts*. The neutral falts, on the contrary, are of a fecondary order of combination, being formed by the union of two *mixts* with each other, and may therefore

therefore be termed *compounds*. Hence I ſhall not arrange the alkalies * or earths in the claſs of ſalts, to which I allot only ſuch as are compoſed of an oxygenated ſubſtance united to a ſalifiable baſe.

I have already enlarged ſufficiently upon the formation of acids in the preceding chapter, and ſhall not add any thing farther upon that ſubject; but having as yet taken no notice of the ſalifiable baſes which are capable of uniting with them to form neutral ſalts, I mean, in this chapter, to give an account of the nature and origin of each of theſe baſes. Theſe are potaſh, ſoda, ammoniac, lime, magneſia, barytes, argil †, and all the metallic bodies.

§ 1. *Of Potaſh.*

We have already ſhewn, that when a vegetable ſubſtance is ſubmitted to the action of fire

* Perhaps thus rejecting the alkalies from the claſs of ſalts may be conſidered as a capital defect in the method here adopted, and I am ready to admit the charge; but this inconvenience is compenſated by ſo many advantages, that I could not think it of ſufficient conſequence to make me alter my plan.—A.

† Called Alumine by Mr Lavoiſier: but as Argil has been in a manner naturalized to the language for this ſubſtance by Mr Kirwan, I have ventured to uſe it in preference.—T.

in diſtilling veſſels, its component elements, oxygen, hydrogen, and carbon, which formed a threefold combination in a ſtate of equilibrium, unite two and two, in obedience to affinities which act conformable to the degree of heat employed. Thus, at the firſt application of the fire, whenever the heat produced exceeds the temperature of boiling water, part of the oxygen and hydrogen unite to form water; ſoon after, the reſt of the hydrogen and part of the carbon combine into oil; and, laſtly, when the fire is puſhed to the red heat, the oil and water, which had been formed in the early part of the proceſs, become again decompoſed, the oxygen and part of the carbon unite to form carbonic acid, a large quantity of hydrogen gas is ſet free, and nothing but charcoal remains in the retort.

A great part of theſe phenomena occur during the combuſtion of vegetables in the open air; but, in this caſe, the preſence of the air introduces three new ſubſtances, the oxygen and azot of the air, and caloric, and, of theſe, two at leaſt produce conſiderable changes in the reſults of the operation. In proportion as the hydrogen of the vegetable, or that which ariſes from the decompoſition of the water, is forced out in the form of hydrogen gas by the progreſs of the fire, it is ſet on fire immediately upon getting into contact with the air, water is again formed, and the greater part of the caloric

ric of the two gafes becoming free produces flame. When all the hydrogen gas is driven out, burnt, and again reduced to water, the remaining carbon continues to burn, but without flame; it is formed into carbonic acid, which carries off a portion of caloric fufficient to give it the gafeous form; the reft of the caloric, from the oxygen of the air, being fet free, produces the heat and light obferved during the combuftion of the carbon. The whole vegetable is thus reduced to water and carbonic acid, and nothing remains but a fmall portion of grey earthy matter called afhes, being the only really fixed principles which enter into the conftitution of vegetables.

The earth, or rather afhes, which feldom exceeds a twentieth part of the weight of the vegetable, contains a fubftance of a particular nature, known under the name of fixed vegetable alkali, or potafh. To obtain this, water is poured upon the afhes, which diffolves the potafh, and leaves the afhes which are infoluble; by afterwards evaporating the water, we obtain the potafh in a white concrete form: It is very fixed even in a very high degree of heat. I do not mean here to defcribe the art of preparing potafh, or the method of procuring it in a ftate of purity, but have entered into the above detail merely that I might not ufe any word, not previoufly explained.

The

The potash obtained by this process, is always less or more saturated with carbonic acid, which is easily accounted for: As the potash does not form, or at least is not set free, but in proportion as the carbon of the vegetable is converted into carbonic acid by the addition of oxygen, either from the air or the water, it follows, that each particle of potash, at the instant of its formation, or at least of its liberation, is in contact with a particle of carbonic acid, and as there is a considerable affinity between these two substances, they naturally combine together. Although the carbonic acid has less affinity with potash than any other acid, yet it is difficult to separate the last portions from it. The most usual method of accomplishing this is to dissolve the potash in water; to this solution two or three times its weight of quicklime are added, then the liquor is filtrated, and evaporated in close vessels; the saline substance left by the evaporation is potash almost entirely deprived of carbonic acid. In this state it is soluble in an equal weight of water, and even attracts the moisture of the air with great avidity; by this property it furnishes us with an excellent means of rendering air or gas dry by exposing them to its action. In this state, it is soluble in alcohol, though not when combined with carbonic acid; and Mr Berthollet employs this property as a method of procuring potash in the state of perfect purity.

All

All vegetables yield lefs or more of potafh in confequence of combuftion, but it is furnifhed in various degrees of purity by different vegetables; ufually, indeed, from whatever fource it be procured, it is mixed with different falts, from which, however, it is eafily feparable. We can hardly entertain a doubt, that the afhes, or earth, which is left by vegetables in combuftion, pre-exifted in them before they were burnt, forming what may be called the fkeleton, or offeous part of the vegetable. But it is quite otherwife with potafh: this fubftance has never yet been procured from vegetables but by means of proceffes or intermedia capable of furnifhing oxygen and azot, fuch as combuftion, or by means of nitric acid; fo that it is not yet demonftrated that potafh may not be a produce from thefe operations. I have begun a feries of experiments upon this fubject, and hope foon to be able to give an account of their refults.

§ 2. *Of Soda.*

Soda, like potafh, is an alkali procured by lixiviation from the afhes of burnt plants, but only from thofe which grow upon the fea-fide, and efpecially from the herb *kali*, whence is derived the name *alkali*, given to this fubftance by the Arabians. It has fome properties in common with potafh, and others which are entirely different: In general, thefe two fubftances have peculiar characters in their faline combinations,

binations, which are proper to each, and consequently diſtinguiſh them from each other: thus ſoda, which, as obtained from marine plants, is uſually entirely ſaturated with carbonic acid, does not attract the humidity of the atmoſphere like potaſh, but, on the contrary, it deſiccates, its cryſtals effloreſce, and are converted into a white powder having all the properties of ſoda, which it really is, having only loſt its water of cryſtallization.

Hitherto we are not better acquainted with the conſtituent elements of ſoda than with thoſe of potaſh, being equally uncertain whether it previouſly exiſted ready formed in the vegetable, or if it be a combination of elements effected by combuſtion. Analogy leads us to ſuſpect, that azot is a conſtituent element of all the alkalies, as is the caſe with ammoniac; but we have only ſlight preſumptions, unconfirmed by any deciſive experiments, reſpecting the compoſition of potaſh and ſoda *.

§ 3. *Of*

* There are ſome experiments related in the Tranſactions of the Turin Academy, which give reaſon for ſuppoſing that ſoda is a modification of magneſia: This latter ſubſtance, according to the experiments detailed by Baron Born, and mentioned in the additional ſection of this chapter, ſeems to be a metallic oxyd. From analogy we may preſume, that potaſh is likewiſe a metallic ſubſtance, in ſome hitherto unknown ſtate of combination. We ſhall thus exclude all the alkalies from the claſs of ſimple elementary ſubſtances.—T.

§ 3. *Of Ammoniac.*

We have, however, very accurate knowledge of the compoſition of ammoniac or volatile alkali, as it is called by the old chemiſts. Mr Berthollet, in the Memoirs of the Academy for 1784, p. 316. has proved by analyſis, that 1000 parts of this ſubſtance conſiſt of about 807 parts of azot combined with 193 parts of hydrogen.

Ammoniac is chiefly procurable from animal ſubſtances by diſtillation, during which proceſs the azot and hydrogen neceſſary to its formation unite in proper proportions; it is not, however, procured pure by this proceſs, being mixed with oil and water, and moſtly ſaturated with carbonic acid. To ſeparate theſe ſubſtances, it is firſt combined with an acid, the muriatic for inſtance, and then diſengaged from that combination by the addition of lime or potaſh. When ammoniac is thus produced in its greateſt degree of purity, it can only exiſt under the gaſeous form, at leaſt in the uſual temperature of the atmoſphere; it has an exceſſively penetrating ſmell; it is abſorbed in large quantities by water, eſpecially if cold, and aſſiſted by compreſſion. Water thus ſaturated with ammoniac has uſually been termed volatile alkaline fluor; we ſhall call it either ſimply ammoniac, or liquid ammoniac,

niac, and ammoniacal gas when it exifts in the aëriform ftate *.

§ 4. *Of Lime, Magnefia, Barytes, Argil, Strontites, Zircon, Glucine, Yttria, and Aguftine.*

The compofition of thefe earths is totally unknown, and until, by new difcoveries, their conftituent elements are afcertained, we are certainly authorifed to confider them as fimple bodies. Art has no fhare in the production of thefe earths, as they are all procured ready formed from nature; but, as they have all, efpecially the three firft, great tendency to combination, they are never found pure. Lime is ufually faturated with carbonic acid in the ftate of chalk, calcareous fpars, moft of the marbles, &c.; fometimes with fulphuric acid, as in gypfum and plafter ftones; at other times with fluoric acid forming vitreous or fluor fpars; and, laftly, it is found in the waters of the fea, and of faline fprings,

* The nomenclature of the alkalies propofed by Dr Black feems better than that adopted by Mr Lavoifier and the French chemifts. *Lixa*, *trona*, and *ammona*, are equally convenient for ufe as potaffa or potafh, foda, and ammoniac, and they are not fo apt to lead into miftakes; for the words of the new French chemical nomenclature have too much refemblance to old terms ufed for very different fubftances, or at leaft for very different ftates, in a chemical light, of the fame fubftances.—T.

ſprings, combined with muriatic acid. Of all the ſaliſiable baſes, it is the moſt univerſally ſpread through nature.

Magneſia is found in mineral waters, for the moſt part combined with ſulphuric acid; it is likewiſe abundant in ſea-water, united with muriatic acid; and it exiſts in a great number of ſtones of different kinds.

Barytes is much leſs common than the two preceding earths; it is found in the mineral kingdom, combined with ſulphuric acid, forming heavy ſpars, and ſometimes, though rarely, united to carbonic acid.

Argil, or the baſe of alum, having leſs tendency to combination with the other earths, is often found in the ſtate of argil, uncombined with any acid. It is chiefly procurable from clays, of which, properly ſpeaking, it is the baſe, or chief ingredient *.

" On the 4th of November 1793, Dr Hope, now Profeſſor of Chemiſtry in the Univerſity of Edinburgh, read to the Royal Society of Edinburgh, a very elaborate analyſis of a nondeſcript mineral from the mines of Strontian in Argyleſhire; to which, from its place and ſtructure, he gives the name of *Strontitic-ſpar;* and which

* For reaſons ſimilar to thoſe given in the preceding note, Dr Black propoſed to name theſe four ſimple earths, Calca, Magneſia, Baryta and Arga.—T.

which he finds to confift of a peculiar earth, hitherto undifcovered in any other mineral body, combined with carbonic acid. To this earth he has affigned the name of *Strontites*, which agrees very well with the new nomenclature ; only that, perhaps, Strontita would have been more regular, for the reafons mentioned in the two preceding notes. In this elementary treatife, a detailed account of this important difcovery cannot be given ; for which the reader is referred to the Tranfactions of the Royal Society of Edinburgh. Strontites has a pungent acrid tafte ; is foluble both in hot and cold water, but much more fo in hot, from which it cryftallizes in cooling; its cold folutions attract carbonic acid from the atmofphere, form a cruft of carbonate of Strontites on the furface, which breaks and falls to the bottom, exactly as in lime, and is rediffolved by an excefs of acid. Strontites combines with the various acids, forming neutral falts ; and poffeffes different affinities with the acids from the other known earths. One of its moft remarkable properties, both when pure and in combination with the acids, is that of tinging the flame of combuftible bodies of a deep blood red colour ; to produce which effect, however, fome moifture muft be prefent. The order of affinities of the principal acids with Strontites, as determined by Dr Hope's experiments, is as follows :

Sulphuric.

Sulphuric.	Nitric.	Acetous.
Oxalic.	Muriatic.	Arſeniac.
Tartarous.	Succinic.	Boracic.
Fluoric.	Phoſphoric.	Carbonic.

Its order of affinities with the ſeveral acids, relative to the other ſalifiable baſes, ſo far as aſcertained by Dr Hope, are inſerted in the reſpective tables in Part II *."

"Several new earths †, or what have been ſuppoſed ſuch, have lately been diſcovered by different foreign chemiſts. Klaproth, in his analyſis of the jargon, thinks he has detected a new earth, to which he gives the name of *Zircon*, and which conſtitutes 68 hundredth parts of that foſſil; the reſt being ſilex, with half a part of iron combined with nickel. Zircon is white, harſh, and inſipid; its ſpecific gravity being to water as 4.300 to 1.000. It is inſoluble in water, but unites into a gelatinous maſs, which becomes hard and ſemi-tranſparent when dry. It does not diſſolve in a ſolution of potaſh or ſoda, even by boiling. With the blow-pipe, even with the alkalies, it is infuſible; but runs into a tranſparent colourleſs glaſs with borax. With

* The whole of this account of Strontites, was added by the tranſlator to the third edition.—T.

† This account of the new earths is added to the preſent edition by the tranſlator.—T.

intenſe heat, it becomes vitreſcent *per ſe*, and is then extremely hard. It forms neutral ſalts with the acids; and theſe are decompoſible by all the alkalies, and by heat alone."

" Vauquelin gives the name of *Glaucine*, to an earth which he has diſcovered in the emerald and beryl. It is white, light, ſoft, inſipid, and adheres ſlightly to the tongue. It is not ſoluble in water, nor fuſible *per ſe*. It is ſoluble in the pure fixed alkalies, and in carbonat of ammonia. With moſt of the acids it enters into combinations, forming neutral ſalts of a highly ſaccharine taſte. Its affinities with the acids are intermediate between thoſe of magneſia and argil."

" Gadolin, in a new foſſil named Ytterby, has detected a new earth, which he calls Yttria. It is white, ſmooth, and inſipid; inſoluble in the alkalies; infuſible alone, but vitrifies with borax; forms neutral ſalts with the acids, and is precipitated by ammonia, by pruſſiat of potaſh, and by *tanin*. Its ſalts are different in taſte from thoſe of glaucine; and, as ſome of its ſalts are coloured, it has been conſidered as intermediate between the earths and metals."

" Trommſdorf, in the Saxon beryl, thinks he has diſcovered a new earth, which he calls *Aguſtine*, from its ſalts being taſteleſs. It is inſoluble in the alkalies, either in the humid or dry way of operating; inſoluble in water; but ſome-

what

what ductile. In a ſtrong heat it becomes very hard. With the acids it forms neutral ſalts."

§ 5. *Of Metallic Bodies.*

The metals, except gold, and ſometimes ſilver, are rarely found in the mineral kingdom in their metallic ſtate, being uſually leſs or more ſaturated with oxygen, or combined with ſulphur, arſenic, ſulphuric acid, muriatic acid, carbonic acid, or phoſphoric acid. Metallurgy, or the docimaſtic art, teaches the means of ſeparating them from theſe foreign matters; and for this purpoſe, we refer to ſuch chemical books as treat upon theſe operations.

We are probably only acquainted as yet with a part of the metallic ſubſtances exiſting in nature, as all thoſe which have a ſtronger affinity to oxygen than carbon poſſeſſes, are incapable, hitherto, of being reduced to the metallic ſtate, and conſequently, being only preſented to our obſervation under the form of oxyds, are confounded with earths. It is extremely probable that barytes, which we have juſt now arranged with earths, is in this ſituation; for in many experiments it exhibits properties nearly approaching to thoſe of metallic bodies. It is even poſſible that all the ſubſtances we call earths may be only metallic oxyds, irreducible by any hitherto known proceſs.

 Thoſe

Thoſe metallic bodies we are at preſent acquainted with, and which we can reduce to the metallic or reguline ſtate, are the following ſeventeen.

	Latin Names.	*Engliſh Names.*
1.	Arſenicum -	Arſenic.
2.	Molybdenum -	Molybdena.
3.	Tungſtenum -	Tungſtein.
4.	Manganeſum -	Manganeſe.
5.	Nickolum -	Nickel.
6.	Cobaltum -	Cobalt.
7.	Biſmuthum -	Biſmuth.
8.	Antimonium -	Antimony.
9.	Zincum -	Zinc.
10.	Ferrum -	Iron.
11.	Stannum -	Tin.
12.	Plumbum -	Lead.
13.	Cuprum -	Copper.
14.	Mercurium -	Mercury.
15.	Argentum -	Silver.
16.	Aurum -	Gold.
17.	Platinum -	Platina *.

I

* To theſe, may now be added the following new metals:

18. Barytum.
19. Magneſium.
20. Calcum.
21. Uranium.
22. Titanium.
23. Tellurium.
24. Chromum.

For which ſee the immediately ſubſequent Section, added entirely by the Tranſlator.—T.

I only mean to conſider theſe as ſalifiable baſes, without entering at all upon the conſideration of their properties in the arts, and for the uſes of ſociety. In theſe points of view, each metal would require a complete treatiſe, which would lead me far beyond the bounds I have preſcribed for this work.

§ 6. *Of the Metallic Nature of the Earths; and of ſeveral newly-diſcovered Metals* *.

" In the laboratory of the Academy of the mines at Chemnitz in Lower Hungary, ſome experiments have been lately made, by Meſſrs Tondi and Ruprecht, by which the number of the metals ſeems to be conſiderably augmented. Beſides aſcertaining the real metallic nature of Tungſtein, Molybdena, and Manganeſe, which ſome chemiſts had doubted, but all of which have been reduced to the reguline form

* The whole of this ſection has been added by the Tranſlator. So much as refers to Barytes, Magneſia, Chalk, and Uranium, was inſerted in the ſecond, third, and fourth editions: What relates to Titanium, Tellurium, and Chromum, is now firſt added to this fifth edition.—T.

form by these two chemists, they have succeeded in procuring metallic reguli from Chalk, Magnesia, and Barytes. Of these experiments, it may be proper to give some account in this place, from the description of the cabinet of Mademoiselle Raab of Vienna, by Baron Born."

Barytes.

" After having purified some Barytes, by repeated fusions and precipitations, it was mixed with an eighth part of its weight of powdered charcoal, and made into a paste with lintseed oil: this was put into a crucible, surrounded by powdered charcoal, and submitted to a strong melting heat for an hour and a half. A perfect metallic regulus was procured, of an iron-grey colour and uniform metallic lustre: its texture is lamellated, composed of large distinct lamellæ, which cross each other: it is brittle, but not hard, and readily takes a polish; is attracted by the magnet, notwithstanding every possible precaution to separate any martial oxyd which might have previously been mixed with the mineral. The specific gravity of this new metal is 6.744, water being taken as unity."

Magnesia.

Magnesia.

"By treating the carbonat of magnesia in the same manner, they obtained a convex lump or globule of metallic regulus, of a bright grey colour, similar to platina which has not been fully purified from iron. This regulus is harder than those obtained from tungstein or molybdena; it is granular and somewhat striated in its texture when broken, and is not affected by the magnet. Its specific gravity and other properties have not yet been ascertained."

Chalk.

"By the same method of proceeding, a regulus has likewise been procured from carbonat of chalk. The button was convex, and very compact in its texture; in colour and lustre it came very near to the appearance of platina, and it took a fine polish. Its specific gravity, and chemical relations, have not yet been ascertained by experiment."

"These experiments have been frequently repeated by the above-mentioned gentlemen, and always with the same results. Should they eventually be confirmed by rigorous examination, a new light will be thrown on several of

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the moſt difficult parts of chemiſtry by theſe diſcoveries, which have already been in a great meaſure predicted, by the conjecture of Mr Lavoiſier, who ſuppoſes that thoſe ſubſtances, which have long been conſidered as primitive earths, are only metallic oxyds combined with oxygen, and that their reduction has hitherto been prevented by the attraction which ſubſiſts between them and oxygen being ſtronger than that between oxygen and carbon."

Mr Baron Born adds to the above account, " that he expects ſoon to learn that the ſiliceous " and argillaceous earths are likewiſe metallic " oxyds, and that, in this caſe, the whole claſs " of earths and ſtones will diſappear from the " mineral kingdom. The diſcovery is certainly " one of the moſt important that modern che- " miſtry has produced for a long while; it muſt " have great influence in changing our metal- " lurgic proceſſes, which will thereby become " more certain in their reſults, and more ſcien- " tific in their application; even every branch " of chemiſtry may receive conſiderable light " and improvement from their influence. Per- " haps gold and ſilver are the only pure metal- " lic ſubſtances hitherto known, as it is proba- " ble, that ſome part of the, till now unknown, " metals, from the earths employed for facilita- " ting the ſmelting of ores, may mix with the " metals which we extract from theſe ores, and

" debaſe

" debaſe them; ſo that, inſtead of ſimple or " pure metals, which they were formerly con- " ſidered, theſe may only be alloys, of the in- " gredients of which we are ſtill ignorant. Per- " haps the regulus of barytes and of chalk are " ſoluble in the ſame acids, and precipitated by " the ſame elective attractions, as the regulus " of copper, which may be the cauſe of this " mixture not being hitherto ſuſpected. From " this mixture, or alloyage, the harſhneſs and " greater or leſſer ductility of iron, copper, tin, " and other metals, may be derived. All theſe " conjectures can only be aſcertained or reject- " ed, when all theſe newly-diſcovered metals " ſhall have been properly examined, and their " chemical affinities compared accurately with " thoſe of the metals already known, and with " each other. One thing ſeems highly proba- " ble, that one or other of theſe new metals " will precipitate ſome of the other metals from " ſolutions in a metallic form, and by this pro- " perty many metallurgic proceſſes may become " greatly facilitated and abridged."

" Theſe diſcoveries give reaſon to hope that chemiſtry may one day arrive at a moſt beautiful ſtate of ſimplicity. It is perhaps no improbable conjecture, that all the bodies in nature may be referred to one claſs of ſimple combuſtible elementary ſubſtances, to oxygen, and to caloric; and that, from the various combinations

nations of theſe with each other, all the variety produced by nature and art may ariſe. The only known difference between metals and pure combuſtibles, as they are called, is in degrees of qualities: They are all combuſtible, that is, they all combine with oxygen, though under different degrees of temperature: They are all ſolid, or liquid, or aëriform, fixed or volatile at different temperatures: In different degrees of ſaturation with oxygen, they form oxyds, which have alkaline properties or acids. In the ſtate of oxyds, the formerly known metals have all the properties of what were formerly called primitive earths, which are now at leaſt ſuſpected of being metallic oxyds: Even the aëriform nature of hydrogen and azot, which does not ſeparate them from the reſt ſo far as combuſtibility is concerned, is only a difference in degree of volatility. We do not exclude mercury from the metals, becauſe it is volatile in the temperature of 600°, and fuſes at —40°, though iron is fixed at 24000°, according to Mr Wedgewood's experiments, and requires 25077° for its fuſion; why then ſhould hydrogen and azot be excluded from a claſs with which they agree in ſo many particulars, becauſe their points of fuſion and volatility are perhaps as many degrees below thoſe belonging to mercury as this latter falls ſhort of thoſe of iron; or why ſhould carbon, ſulphur, and phoſphorus, not be

be confidered as metals, becaufe their fpecific gravity, and luftre, and ductility, differ from the bodies called metals, which differ fo much in thefe particulars among themfelves?

"To thefe three new metals Mr Tondi wifhes to give the names of *borbonium*, for the regulus of barytes; *auftrum*, for the regulus from magnefia; and *parthenum* for that of chalk. It were hard to deny a difcoverer the right of giving names to his own difcoveries, without fome reafonable objection; but thefe names would introduce confufion into chemical nomenclature, which it has been the great object of the French chemifts to reform, and render regular; wherefore I would propofe that they fhould be named *barytum*, *magnefium*, and *calcum*: Thefe accord with the reformed old names of the fubftances from which they are procured, merely by changing to the neuter gender, in which all the names of the metals are placed in the new nomenclature, and then the three, formerly called earths, will be oxyds of thefe metals refpectively, or *baryta*, *magnefia*, and *calca*, if fingle terms are preferred, thefe latter being in the feminine gender, which is appropriated to alkaline fubftances in the new nomenclature.

"It muft not, however, be concealed, that the truth of thefe difcoveries is ftrongly contefted

tested by very eminent chemists; who insist that the metallic buttons, produced in the experiments of Messrs Tondi and Ruprecht, arise entirely from the manganese and iron of the charcoal, or from some similar alloyage of materials from the crucibles or tests employed, and that they have no farther pretensions to be considered as distinct metals than the siderite, now known to be phosphorated iron, or than plumbago, or black-lead."

"Mr Klaproth, a celebrated chemist at Berlin, has lately discovered a new metal, to which he gives the name of *Uranium;* and he distinguishes its various mineral forms by the generic term of Uranite. His numerous experiments on this subject are published in Crell's Chemical Journal, and in the Annales de Chymie; and the following general account of the minerals, and of the metal, was considered as proper to be given in this place.

"The Uranite occurs in several forms which were formerly overlooked, by chemists and mineralogists, being considered as very poor ores of copper, because they mostly contain a little of that metal: They are chiefly found near Johan-georgen Stadt in Saxony, Salfeldt in Thuringia, and Joachims-thal in Bohemia: These may be divided into three genera, the ochreous, the spathiform, and the mineralized,

zed, or ore. The ochreous, or uranite ochre, called *uranit-oker*, in the German language, is of a lemon yellow colour of various ſhades, and being frequently more or leſs mixed with iron ochre, its colour is thereby changed to various ſhades of brown; ſometimes it is in a powdery ſtate, and at other times it is caked together in maſſes of different degrees of compactneſs; it is generally found covering or adhering to pieces of the mineralized uranite. The ſpathiform, or uranite ſpar, called in German *uranit-ſpath*, the *chalkolith* of Mr Werner, is generally of a deep graſs green colour, ſometimes verging to a ſilver white, and at other times to a light yellowiſh green; it is ſometimes compact and irregular in its form, and is ſometimes cryſtallized in ſmall ſhining ſquare and tranſparent tables, which are occaſionally ſo thick as to be almoſt cubes: theſe cryſtals are lamellated in the fracture, and feel ſoft to the touch: they are often found in ſpots, ſcattered over the ſurface of micaceous ſhiſt, granite, or a mixture of quartz and black uranite ore. Both the ochre and ſpar diſſolve entirely in nitric acid. The mineralized, or uranite ore, called in German *uranit-erz*, *pech-blende*, or *pech-erz*, is of a dark black-brown colour: it is tolerably hard, has a greaſy luſtre, breaks compact, and is black where ſcratched: it is very heavy,

heavy, the ſpecific gravity being 7.500: it does not melt in the fire by itſelf, but is reduced under the blow-pipe with the addition of phoſphoric acid, to a green vitreous globule: it diſſolves imperfectly in the acids, but beſt in the nitrous, the diſſolution being of a pale white-wine colour.

"Uranium, the metal procured from theſe mineral ſubſtances, is even more difficultly fuſed than manganeſe: its ſpecific gravity is 6.440: it is of a dark grey colour, becoming brown when ſcratched: its brilliancy is ſlight; and it is rather ſoft, being eaſily cut with a knife or file. It diſſolves very imperfectly in the ſulphuric and muriatic acids, but very readily, and with conſiderable evolution of heat, in nitric and nitro-muriatic acids: From this diſſolution its oxyd is precipitated of a yellow colour by the pure alkalies, and the precipitates are re-diſſolved by an exceſs of alkali: with the alkaline carbonats the precipitates are whitiſh, and reddiſh brown when the pruſſiats are employed: Theſe oxyds do not melt under the blow-pipe, without addition, but with ſoda and borax they melt into a brown button, and with phoſphoric acid the button is of a green colour."

"In * a grayiſh-black metallic ſand, found in the vale of Menachan in Cornwall, Mr Macgregor

* The remainder of this ſection is added by the Tranſlator to the preſent edition.—T.

gregor has lately detected a peculiar metallic oxyd, mixed with filex and the oxyds of iron and manganefe, to which he gives the name of Menachanite. Klaproth has fince difcovered the fame in the red fchorl of the Hungarian mines, and in a mineral named Siderotitanium, from which he calls the new metal *Titanium.* The oxyd is red; but when partially reduced, by heating with inflammable fubftances, it becomes yellow or blue. It is very hard and infufible. By means of heat, it is diffolved in dilute fulphuric, nitric, and muriatic acids, affuming a gelatinous confiftence. From this folution cryftals are obtained by fpontaneous evaporation; but thefe falts are decompofed by boiling. They are likewife decompofed by pruffiat of potafh and by gallic acid; the former giving a green precipitate, and the latter a brownifh red. Vauquelin has been able to deoxydate this metal, though extremely refractory, and apparently volatile. It is brittle, of a cryftalline ftructure, and reddifh-yellow in its colour; and will not unite with any of the metals except iron."

"From an ore of gold called aurum problematicum, and feveral other ores of that metal, Muller and Klaproth have extracted a new metal, to which has been given the name of *Tellurium.* It is white or greyifh, with confiderable luftre; brittle, lamellated, and its fur-

face

face becomes cryſtalline on cooling: It is very fuſible, and extremely volatile, burning with a blue flame when much heated. The oxyd is white, becoming yellow when heated; is eaſily volatilized, and very readily reducible. Tellurium diſſolves in nitric and nitro-muriatic acids, from the latter of which its oxyd is precipitated by water. With ſulphuric acid it forms a fine red ſolution; the colour of which diſappears by heat, or by dilution with water. From all theſe ſolutions the oxyd is precipitated by all the alkalies, but is rediſſolved by exceſs of alkali. Iron, zinc, tin, and antimony, precipitate it from theſe ſolutions in a metallic ſtate. It amalgamates with mercury, and alloys with ſeveral of the metals. Its ſpecific gravity is 6.115."

"From the red lead ore of Siberia, Vauquelin has lately extracted a metallic ſubſtance, to which he gives the name of *Chrome*, or *Chromum*, from its property of giving brilliant colours to moſt of its combinations. In the Siberian red lead ore, this metal exiſts in the ſtate of an acid; and it has likewiſe been found ſimilarly combined with iron. The ſame chemiſt has aſcertained that the emerald owes its colour to the oxyd of this metal, and ſuſpects it to ſerve the ſame purpoſe in other gems. The acid of chromum, or the chromic acid, is of a fine ruby colour, and forms

priſmatic

prifmatic cryftals, which are foluble in water, having a fharp metallic tafte. Chromic acid combines with the alkalies, forming golden yellow cryftallizable falts. It combines with all the metals, forming compounds of fplendid colours. With phofphoric acid, or borat of foda, it fufes into vitreous globules of a fine emerald green colour. When heated with muriatic acid, it lofes part of its oxygen; oxygenated muriatic acid is formed, and the oxyd of chromum is diffolved, giving a rich deep green colour to the folution. The red chromic acid may likewife be reduced to a green oxyd, by heating it with the blow-pipe in contact with charcoal. Chromic acid is reduced to the metallic ftate, by expofure to violent heat, completely bedded in powdered charcoal. The metal is greyifh, brittle, brilliant, difficultly fufed, and difpofed to cryftallize, in cooling. When heated in contact with air, its furface changes to a green oxyd. It may be oxygenated, but with great difficulty, by diftilling from it to drynefs, twenty times its weight of concentrated nitric acid, feveral times fucceffively."

"Although chemical analyfis is now reduced to great accuracy, it is not impoffible that fome of thefe new metallic fubftances may turn out only very refractory combinations

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of already known metals. The ſiderite of Scheele and Bergman, ought to make chemiſts extremely cautious of pronouncing definitively on ſuch diſcoveries. This remark may likewiſe be applied to the newly-diſcovered earths."

CHAP.

CHAP. XVII.

Continuation of the Obſervations upon Salifiable Baſes, and the Formation of Neutral Salts.

IT is neceſſary to remark, that earths and alkalies unite with acids to form neutral ſalts without the intervention of any medium, whereas metallic ſubſtances are incapable of forming this combination, without being previouſly leſs or more oxygenated; ſtrictly ſpeaking, therefore, metals are not ſoluble in acids, but only metallic oxyds. Hence, when a metal is put into an acid for ſolution, it is neceſſary, in the firſt place, that it become oxygenated, either by attracting oxygen from the acid, or from the water with which the acid is diluted; or, in other words, that a metal cannot be diſſolved in an acid, unleſs the oxygen either of the acid, or of the water mixed with it, has a ſtronger affinity to the metal than to the hydrogen or the acidifiable baſe; or what amounts to the ſame thing, that no metallic diſſolution can take place, without a previous decompoſition of the water, or of the acid in which it is made. The explanation of the principal phenomena of me-

tallic

tallic diſſolution depends entirely on this ſimple obſervation, which was overlooked even by the illuſtrious Bergman.

The firſt and moſt ſtriking of theſe phenomena is the efferveſcence, or, to ſpeak leſs equivocally, the diſengagement of gas, which takes place during the ſolution; in the ſolutions made in nitric acid, this efferveſcence is produced by the diſengagement of nitrous gas; in ſolutions with ſulphuric acid it is either ſulphurous acid gas or hydrogen gas, according as the oxydation of the metal happens to be made at the expence of the ſulphuric acid or of the water. As both nitric acid and water are compoſed of elements which, when ſeparate, can only exiſt in the gaſeous form, at leaſt in the common temperature of the atmoſphere, it is evident that, whenever either of theſe is deprived of its oxygen, the remaining element muſt inſtantly expand and aſſume the ſtate of gas; the efferveſcence is occaſioned by this ſudden converſion from the liquid to the gaſeous ſtate. The ſame decompoſition, and conſequent formation of gas, takes place when ſolutions of metals are made in ſulphuric acid: In general, eſpecially by the humid way, metals do not attract all the oxygen it contains; they therefore reduce it, not into ſulphur, but into ſulphurous acid, and as this acid can only exiſt as gas in the uſual temperature,

perature, it is disengaged, and occasions effervescence.

The second observable phenomenon is, that, when the metals have been previously oxydated, they all dissolve in acids without effervescence: This is easily explained; because, not having now any occasion for combining with oxygen, they neither decompose the acid nor the water, by which decomposition, in the former case, the effervescence is occasioned.

A third phenomenon, which requires particular consideration, is, that none of the metals produce effervescence by solution in oxygenated muriatic acid. During this process the metal, in the first place, carries off the excess of oxygen from the oxygenated muriatic acid, by which it becomes oxydated, and reduces the acid to the state of ordinary muriatic acid. In this case there is no production of gas; not that the muriatic acid does not tend to exist in the gaseous state in the common temperature, which it does equally with the acids formerly mentioned, but because this acid, which otherwise would expand into gas, finds more water combined with the oxygenated muriatic acid than is necessary to retain it in the liquid form; hence it does not disengage like the sulphurous acid, but remains, and quietly dissolves and combines with the metallic oxyd previously formed from its superabundant oxygen.

The fourth phenomenon worthy of notice is, that metals are abſolutely inſoluble in ſuch acids as have their baſes joined to oxygen by a ſtronger affinity than theſe metals are capable of exerting upon that acidifying principle. Hence ſilver, mercury, and lead, in their metallic ſtates, are inſoluble in muriatic acid, but, when previouſly oxydated, they become readily ſoluble without efferveſcence.

From theſe phenomena it appears that oxygen is the bond of union between metals and acids; and from this we are led to ſuppoſe that oxygen is contained in all ſubſtances which have a ſtrong affinity with acids: Hence it is very probable that the four eminently ſalifiable earths contain oxygen, and that their capability of uniting with acids is produced by the intermediation of that element. What I have formerly noticed relative to theſe earths, viz. that they may very poſſibly be metallic oxyds, with which oxygen has a ſtronger affinity than with carbon, and conſequently are not reducible by any known means, is conſiderably ſtrengthened by the above conſiderations.

All the acids hitherto known are enumerated in the following table; the firſt column contains the names of the acids, according to the new nomenclature, in Latin; in the ſecond column, the Engliſh names, according to the ſame nomenclature,

menclature, are placed; the third contains the bafes or radicals of thefe acids.

Table of all the known Acids.

Latin Names.	*Englifh Names.*	*Bafes.*
1. Acidum fulphurofum	Sulphurous acid	Sulphur
2. —— fulphuricum	Sulphuric	
3. —— phofphorofum	Phofphorous	Phofphorus
4. —— phofphoricum	Phofphoric	
5. —— muriaticum	Muriatic	Unknown †
6. ——— oxygenatum *	Oxygenated muriatic	
7. —— nitrofum	Nitrous	Azot
8. —— nitricum	Nitric	
9. ——— oxygenatum ‡	Oxygenated nitric	
10. —— carbonicum	Carbonic	Carbon
11. —— acetofum	Acetous	Compound, See Obf. 1ft.
12. —— aceticum	Acetic	
13. —— oxalicum	Oxalic	
14. —— tartarofum	Tartarous	
15. —— pyro-tartarofum	Pyro-tartarous	
16. —— citricum	Citric	
17. —— malicum	Malic	
18. —— pyro-lignofum	Pyro-lignous	
19. —— pyro-mucofum	Pyro-mucous	

20. Acidum

* This term might be changed for Acidum murioxicum, Murioxic acid.—T.

† In a former note Hydrogen is mentioned as the fuppofed bafe of this acid.—T.

‡ This might more conveniently be named Acidum nitroxicum, or Nitroxic acid.—T.

Latin Names.	*Engliſh Names.*	*Baſes.*
20. Acidum gallicum	Gallic	
21. —— pruſſicum	Pruſſic	
22. —— benzoicum	Benzoic	
23. —— ſuccinicum	Succinic	Compound, See Obſ. 2d.
24. —— camphoricum	Camphoric	
25. —— lactlcum	Lactic	
26. —— ſaccho lacticum	Saccho lactic	
27. —— bombicum	Bombic	
28. —— formicum	Formic	Compound, See Obſ. 3d.
29. —— ſebacicum	Sebacic	
30. —— boracicum	Boracic	Unknown
31. —— fluoricum	Fluoric	
32. —— antimonicum	Antimonic	Antimony
33. —— argenticum	Argentic	Silver
34. —— arſeniacum	Arſeniac *	Arſenic
35. —— biſmuthicum	Biſmuthic	Biſmuth
36. —— cobalticum	Cobaltic	Cobalt
37. —— cupricum	Cupric	Copper
38. —— ſtannicum	Stannic	Tin
39. —— ferricum	Ferric	Iron
40. —— manganicum	Manganic	Manganeſe
41. —— mercuricum †	Mercuric	Mercury
42. —— molybdicum	Molybdic	Molybdena
43. —— nickolicum	Nickolic	Nickel
44. —— auricum	Auric	Gold

45. Acidum

* This term differs a little from the general rule, in making the name terminate in *ac* inſtead of *ic*. The baſe and acid are diſtinguiſhed in French by Arſen*ic* and Arſen*ique*; but, as the ſyllable *ic* was thought moſt convenient for the Engliſh tranſlation of the French *ique*, it became neceſſary to uſe this ſmall deviation.—T.

† Mr Lavoiſier has *Hydrargirique*; but Mercurium being uſed for the metal or baſe, the name of this acid, as above, is at leaſt equally regular, and leſs harſh.—T.

	Latin Names.	*English Names.*	*Bases.*
45.	Acidum platinicum	Platinic	Platina
46.	—— plumbicum	Plumbic	Lead
47.	—— tungsticum	Tungstic	Tungstein
48.	—— zincicum	Zincic	Zinc
49.	—— chromicum	Chromic	Chromum
50.	—— zoonicum	Zoonic	Compound
51.	—— subericum	Suberic	Compound *

Observations on the foregoing Table.

1*st*, The bases or radicals of the acids from N° 11. to N° 19. inclusive, seem to be formed by a combination of carbon and hydrogen; and the only difference appears to proceed from the dissimilar proportions in which these elements combine to form the bases of these acids, together with the different quantities of oxygen in their acidification. A connected series of accurate experiments is still wanted to illustrate this subject in a satisfactory manner.

2*d*, The bases or radicals of the acids from N° 20. to 26. inclusive, are hitherto very imperfectly known; we only know that hydrogen and carbon are their principal elements, and that the prussic acid contains likewise some azot.

3*d*, The bases of the acids 27, 28, 29, and all others obtained from animal substances, are still very imperfectly known, and require farther investigation; for they seem to consist of carbon, hydrogen, phosphorus, and azot, united together, but the particular proportions of these elements

* These three last are newly-discovered acids.—T.

ments in each, and the degrees of oxydation, are unafcertained.

In this lift, which contains 48 acids*, I have enumerated 17 metallic acids hitherto very imperfectly known †, but upon which Mr Berthollet is about to publifh a very important work. It cannot be pretended that all the acids which exift in nature, or rather all the acidifiable bafes, are yet difcovered; but, on the other hand, there are confiderable grounds for fuppofing that a more accurate inveftigation than has hitherto been attempted, will diminifh the number of the vegetable acids, by fhewing that feveral of thefe, at prefent confidered as diftinct acids, are only modifications of others. All that can be done in the prefent ftate of our knowledge is, to give a view of chemiftry as it really is, and to eftablifh fundamental principles, by which fuch bodies as may be difcovered in future may receive names, in conformity with one uniform fyftem.

The

* Together with three added in this edition.—T.

† The lift might have been augmented by the probable acids from the newly-difcovered metals, mentioned in the additional fection of the former chapter: It is not impoffible that the bafes of the Boracic and Fluoric acids may hereafter be difcovered among new metals.

I have left the original numbers of the Author, though many additions have been fince made, for which fee next note.—T.

The known salifiable bases, or substances capable of being converted into neutral salts by union with acids, amount to 24; viz. 3 alkalies, 4 earths, and 17 metallic substances; so that, in the present state of chemical knowledge, the whole possible number of neutral salts amounts to 1152 *. This number is upon the supposition that the metallic acids are capable of dissolving other metals, which is a new branch of chemistry, not hitherto investigated, upon which depends all the metallic combinations named *vitreous*. There is reason to believe that many of these supposable saline combinations are not capable of being formed, which must greatly reduce the real number of neutral salts producible by nature and art. Even if we suppose the real number to amount only to five or six hundred species of possible neutral salts, it is evident, that, were we to distinguish them, after the manner of the older chemists, either by the names of their first discoverers, or by terms derived from the substances from which they are procured, we should at last have such a confusion of arbitrary designations, as no memory could

* This number excludes all triple salts, or such as contain more than one salifiable base, all the salts whose bases are over or under saturated with acid, and those formed by the nitro-muriatic acid.

To these must now be added four new earths, seven new metals, and three new acids, which will very largely increase the possible number of neutral salts.—T.

could poſſibly retain. This method might be tolerable in the early ages of chemiſtry, or even till within theſe twenty years, when only about thirty ſpecies of ſalts were known; but in the preſent times, when the number is augmenting daily, when every new acid gives us 24 or 48 new ſalts, according as it is capable of one or two degrees of oxygenation, a new method is certainly neceſſary. The method here adopted, drawn from the nomenclature of the acids, is perfectly analogical, and, following Nature in the ſimplicity of her operations, gives a natural and eaſy nomenclature, applicable to every poſſible neutral ſalt.

In giving names to the different acids, we have expreſſed the common property by the generical term *acid*, and have diſtinguiſhed each ſpecies by the name of its peculiar acidifiable baſe. Hence the acids formed by the oxygenation of ſulphur, phoſphorus, carbon, &c. are called *ſulphuric acid*, *phoſphoric acid*, *carbonic acid*, &c. We thought it proper likewiſe to indicate the different degrees of ſaturation with oxygen, by different terminations of the ſame ſpecific names: Wherefore we diſtinguiſh between ſulphurous and ſulphuric, and between phoſphorous and phoſporic acids, &c.

By applying theſe principles to the nomenclature of neutral ſalts, we uſe a common term for all the neutral ſalts ariſing from the combinations of one acid, and diſtinguiſh the ſpecies

by

by adding the name of the falifiable bafe. Thus, all the neutral falts having fulphuric acid in their compofition are named *fulphats;* thofe formed by the phofphoric acid, *phofphats*, &c. The fpecies being diftinguifhed by the names of the falifiable bafes gives us *fulphat of potafh*, *fulphat of foda*, *fulphat of ammoniac*, *fulphat of lime*, *fulphat of iron*, &c. As we are acquainted with 24 falifiable bafes, alkaline, earthy, and metallic, we have confequently 24 fulphats, as many phofphats, and fo on through all the acids.

Sulphur is, however, fufceptible of two degrees of oxygenation, the firft of which produces fulphurous, and the fecond, fulphuric acid; and, as the neutral falts produced by thefe two acids have different properties, and are in fact different falts, it becomes neceffary to diftinguifh thofe by peculiar terminations; we have therefore diftinguifhed the neutral falts formed by the acids in the firft or leffer degree of oxygenation, by changing the termination *at* into *ite*, as *fulphites*, *phofphites* *, &c. Thus, oxygenated,

* As all the fpecific names of the acids in the new nomenclature are adjectives, they would have applied feverally to the various falifiable bafes, without the invention of other terms, with perfect diftinctnefs. Thus, *fulphurous potafh*, and *fulphuric potafh*, are equally diftinct, as *fulphite of potafh*, and *fulphat of potafh;* and have the advantage of being more eafily retained in the memory, becaufe

genated or acidified ſulphur, in its two degrees of oxygenation, is capable of forming 48 neutral ſalts, 24 of which are ſulphites, and as many ſulphats: This is likewiſe the caſe with all the acids capable of two degrees of oxygenation *.

It were both tireſome and unneceſſary to follow theſe denominations through all the varieties

cauſe more naturally ariſing from the names of acids themſelves, than the arbitrary terminations adopted by Mr Lavoiſier. Theſe propoſed terms are likewiſe very readily and diſtinctly expreſſible in Latin, thus, *Potaſſa*, or rather, as I have formerly obſerved, *Lixa Sulphuroſa* and *Sulphurica*, and are equally diſtinctive with, and more readily remembered than, the Latin terms of the new nomenclature, *Sulphis* and *Sulphas Potaſſæ*.—T.

* There is yet a third degree of oxygenation of ſeveral acids, as the oxygenated muriatic and oxygenated nitric acids. The terms applicable to the neutral ſalts reſulting from the union of theſe acids with ſalifiable baſes, is ſupplied by the Author in the Second Part of this Work. Theſe are formed by prefixing the word *oxygenated* to the name of the ſalt produced by the ſecond degree of oxygenation. Thus, *oxygenated* muriat of potaſh, *oxygenated* nitriat of ſoda, &c. Or if the change I have propoſed in a former note on the nomenclature of theſe two acids be adopted, we ſhall have *murioxic* and *nitroxic* potaſh or lixa, in Latin *Lixa murioxica*, *Trona nitroxica*, inſtead of the much longer, and not more diſtinctive expreſſions, *Murias potaſſæ oxygenata*, *Nitras ſodæ oxygenata*.—T.

cies of their poſſible applications; it is enough to have given the method of naming the various ſalts, which, when once well underſtood, is eaſily applicable to every poſſible combination. The name of the combuſtible and acidifiable body being once known, the names of the acid it is capable of forming, and of all the neutral combinations the acid is ſuſceptible of entering into, are moſt readily remembered. Such as require a more complete illuſtration of the methods in which the new nomenclature is applied, will, in the Second Part of this book, find Tables which contain a full enumeration of all the neutral ſalts, and, in general, of all the poſſible chemical combinations, ſo far as is conſiſtent with the preſent ſtate of our knowledge. To theſe I ſhall ſubjoin ſhort explanations, containing the beſt and moſt ſimple means of procuring the different ſpecies of acids, and ſome account of the general properties of the neutral ſalts they produce.

I ſhall not deny, that, to render this work more complete, it would have been neceſſary to add particular obſervations upon each ſpecies of ſalt; its ſolubility in water and alcohol; the proportions of acid and of ſalifiable baſe in its compoſition; the quantity of its water of cryſtallization; the different degrees of ſaturation it is ſuſceptible of; and finally, the degree of force or affinity with which the acid adheres to the

the base. This immense work has been already begun by Mess. Bergman, Morveau, Kirwan, and other celebrated chemists, but is hitherto only in a moderate state of advancement; even the principles upon which it is founded are not perhaps sufficiently accurate.

These numerous details would have swelled this elementary treatise to much too great a size; besides that, to have gathered the necessary materials, and to have completed all the series of experiments requisite, must have retarded the publication of this book for many years. This is a vast field for employing the zeal and abilities of young chemists, whom I would advise to endeavour rather to do *well* than to do *much*, and to ascertain, in the first place, the composition of the acids, before entering upon that of the neutral salts. Every edifice which is intended to resist the ravages of time should be built upon a sure foundation; and, in the present state of chemistry, to attempt discoveries by experiments, either not perfectly exact, or not sufficiently rigorous, will serve only to interrupt its progress, instead of contributing to its advancement.

PART II.

Of the Combination of Acids with Salifiable Bafes, and of the Formation of Neutral Salts.

INTRODUCTION.

IF I had ftrictly followed the plan at firft laid down for the conduct of this work, I would have confined myfelf, in the Tables and accompanying obfervations which compofe this Second Part, to fhort definitions of the feveral known acids, and abridged accounts of the proceffes by which they are obtainable, with a mere nomenclature or enumeration of the neutral falts which refult from the combination of thefe acids with the various falifiable bafes. But I afterwards found, that the addition of fimilar Tables of all the fimple fubftances which enter

into the compoſition of the acids and oxyds, together with the various poſſible combinations of theſe elements, would add greatly to the utility of this work, without being any great increaſe to its ſize. Theſe additions, which are all contained in the twelve firſt ſections of this Part, and the Tables annexed to theſe, form a kind of recapitulation of the firſt fifteen Chapters of the Firſt Part; the reſt of the Tables and Sections contain all the ſaline combinations.

It muſt be very apparent, that, in this Part of the Work, I have borrowed largely from what has been already publiſhed by Mr de Morveau in the Firſt Volume of the *Encyclopedie par ordre des Matières*. I could hardly have diſcovered a better ſource of information, eſpecially when the difficulty of conſulting books in foreign languages is conſidered. I make this general acknowledgment on purpoſe to ſave the trouble of references to Mr de Morveau's work, in the courſe of the following part of mine.

TABLE OF SIMPLE SUBSTANCES.

Simple fubftances belonging to all the kingdoms of Nature, which may be confidered as the chemical elements of bodies.

New Names. *Englifh.*	*Latin.*	*Correfpondent Old Names.*
Light		Light.
Caloric	Caloricum	Heat. Principle or element of heat, Fire, Igneous fluid, Matter of fire and of heat.
Oxygen	Oxygenum	Dephlogifticated air, Empyreal air, Vital air, or Bafe of vital air.
Azot	Azotum	Phlogifticated air or gas, Mephitis, or its bafe.
Hydrogen	Hydrogenum	Inflammable air or gas, or the bafe of inflammable air.

Oxydable and Acidifiable fimple Subftances not Metallic.

New Names.		*Correfpondent old Names.*
Sulphur	Sulphurum	The fame names.
Phofphorus	Phofphorum	The fame names.
Carbon	Carbonum	The fimple element of charcoal.
Muriatic radical	Murium	Still unknown.
Fluoric radical	Fluorum	Still unknown.
Boracic radical	Boracum	Still unknown.

Oxydable and Acidifiable fimple Metallic Bodies.

New Names.			*Correfpondent old Names.*
Antimony	Antimonium	Regulus of	Antimony.
Arfenic	Arfenicum	Regulus of	Arfenic.
Bifmuth	Bifmuthum	Regulus of	Bifmuth.
Cobalt	Cobaltum	Regulus of	Cobalt.
Copper	Cuprum	Regulus of	Copper.
Gold	Aurum	Regulus of	Gold.
Iron	Ferrum	Regulus of	Iron.
Lead	Plumbum	Regulus of	Lead.
Manganefe	Manganum	Regulus of	Manganefe.
Mercury	Mercurium	Regulus of	Mercury.
Molybdena	Molybdenum	Regulus of	Molybdena.
Nickel	Nickolum	Regulus of	Nickel.
Platina	Platinum	Regulus of	Platina.
Silver	Argentum	Regulus of	Silver.
Tin	Stannum	Regulus of	Tin.
Tungftein	Tungftenum	Regulus of	Tungftein.
Zinc	Zincum	Regulus of	Zinc.

Salifiable ſimple Earthy Subſtances.

New Names. English.	New Names. Latin.	Correſpondent old Names.
Lime	Calca	Chalk, calcareous earth, Quicklime.
Magneſia	Magneſia	Magneſia, baſe of Epſom ſalt, Calcined or cauſtic magneſia.
Barytes	Byryta	Barytes, or heavy earth.
Argil	Argilla	Clay, earth of alum.
Silex	Silica	Siliceous or vitrifiable earth.
Strontites	Strontyta	Newly diſcovered.

SECT. I. *Obſervations upon the Table of Simple Subſtances.*

The principal object of chemical experiments is to decompoſe natural bodies, ſo as ſeparately to examine the different ſubſtances which enter into their compoſition. By conſulting chemical ſyſtems, it will be found that this ſcience of chemical analyſis has made rapid progreſs in our own times. Formerly oil and ſalt were conſidered as elements of bodies, whereas later obſervation and experiment have ſhewn, that all ſalts, inſtead of being ſimple, are compoſed of an acid united to a baſe. The bounds of analyſis have been greatly enlarged by modern diſcoveries *; the acids are ſhewn to be compoſed of oxygen, as an acidifying principle common to all, united in each to a particular baſe. I have proved, what Mr Haſſenfratz had before advanced,

* See Memoirs of the Academy for 1766, p. 671. and for 1778, p. 535.—A.

advanced, that theſe radicals of the acids are not all ſimple elements, many of them being, like the oily principle, compoſed of hydrogen and carbon. Even the baſes of neutral ſalts have been proved by Mr Berthollet to be compounds, as he has ſhewn that ammoniac is compoſed of azot and hydrogen.

Thus, as chemiſtry advances towards perfection, by dividing and ſubdividing, it is impoſſible to ſay where it is to end; and theſe things we at preſent ſuppoſe ſimple may ſoon be found quite otherwiſe. All we dare venture to affirm of any ſubſtance is, that it muſt be conſidered as ſimple in the preſent ſtate of our knowledge, and ſo far as chemical analyſis has hitherto been able to ſhow. We may even preſume that the earths muſt ſoon ceaſe to be conſidered as ſimple bodies; they are the only bodies of the ſalifiable claſs which have no tendency to unite with oxygen; and I am much inclined to believe that this proceeds from their being already ſaturated with that element. If ſo, they will fall to be conſidered as compounds conſiſting of ſimple ſubſtances, perhaps metallic, oxydated to a certain degree. This is only hazarded as a probable conjecture; and I truſt the reader will take care not to confound what I have related as truths, fixed on the firm baſis of obſervation and experiment, with mere hypothetical ſpeculations.

The fixed alkalies, potaſh, and ſoda, are omitted in the foregoing Table, becauſe, they are evidently compound ſubſtances *, though we are ignorant as yet what are the elements they are compoſed of.

Table

* For the ſame reaſon Calca, Magneſia, and Baryta, ought to have been omitted in this edition, as has been explained in p. 262; but, though the tranſlator has taken the freedom to make ſeveral obſervations and ſome additions, he has not ventured to make any alterations; the latter is the excluſive province of the author.—T.

TABLE *of compound oxydable and acidifiable baſes.*

	Names of the Radicals.	
Oxydable or acidifiable baſes, from the mineral kingdom.	Nitro muriatic radical *, or baſe of the acid formerly called aqua regia.	
Oxydable or acidifiable hydro-carbonous or carbono-hydrous radicals, from the vegetable kingdom.	Tartarous radical or baſe.	
	Malic	Radicals.
	Citric	
	Pyro-lignous	
	Pyro-mucous	
	Pyro-tartarous	
	Oxalic	
	Acetous	
	Succinic	
	Benzoic	
	Camphoric	
	Gallic	
Oxydable or acidifiable radicals from the animal kingdom, which moſtly contain azot, and frequently phoſphorus.	Lactic	
	Saccholactic	
	Formic	
	Bombic	
	Sebacic	
	Lithic	
	Pruſſic	

Note.—The radicals from the vegetable kingdom are converted by a firſt degree of oxygenation into vegetable oxyds, ſuch as ſugar, ſtarch, and gum or mucus: Thoſe of the animal kingdom, by the ſame means, form animal oxyds, as lymph, &c.—A.

* This, for the preſent, may be named Azo-muria, until the radical of muriatic acid be diſcovered; or, at leaſt, till the diſcovery of hydrogen being that radical be unqueſtionably aſcertained.—T

Sect. II.—*Obſervations upon the Table of Compound Radicals.*

The older chemiſts being unacquainted with the compoſition of acids, and not ſuſpecting them to be formed by a peculiar radical or baſe for each, united to an acidifying principle or element common to all, could not conſequently give any name to ſubſtances of which they had not the moſt diſtant idea. We had therefore to invent a new nomenclature for this ſubject, though we were at the ſame time ſenſible that this nomenclature muſt be ſuſceptible of great modification, when the nature of the compound radicals ſhall become better underſtood *.

The compound oxydable and acidifiable radicals from the vegetable and animal kingdoms, enumerated in the foregoing table, are not hitherto reducible to ſyſtematic nomenclature, becauſe their exact analyſis is as yet unknown. We only know in general, by ſome experiments of my own, and ſome made by Mr Haſſenfratz, that moſt of the vegetable acids, ſuch as the tartarous, oxalic, citric, malic, acetous, pyrotartarous, and pyro-mucous, have radicals compoſed of hydrogen and carbon, combined in ſuch

* See Part I. Chap. XI. upon this ſubject.—A.

ſuch a way as to form ſingle baſes, and that theſe acids only differ from each other by the proportions in which theſe two ſubſtance enter into the compoſition of their baſes, and by the degrees of oxygenation which theſe baſes have received. We know farther, chiefly from the experiments of Mr Berthollet, that the radicals from the animal kingdom, and even ſome of thoſe from vegetables, are of a more compound nature, and beſides hydrogen and carbon, that they often contain azot, and ſometimes phoſphorus; but we are not hitherto poſſeſſed of ſufficiently accurate experiments for calculating the proportions of theſe ſeveral ſubſtances. We are therefore forced, in the manner of the older chemiſts, ſtill to name theſe acids after the ſubſtances from which they are procured. There can be little doubt, that theſe names will be laid aſide when our knowledge of theſe ſubſtances becomes more accurate and extenſive; the terms, *hydro-carbonous*, *hydro-carbonic*, *carbono-hydrous*, and *carbono-hydric* *, will then become ſubſtituted for thoſe we now employ, which will then only remain as teſtimonies of the imperfect ſtate in which this part of chemiſtry was tranſmitted to us by our predeceſſors.

It

* See Part I. Chap. XI. upon the application of theſe names according to the proportions of the two ingredients.—A.

It is evident, that the oils, being compofed of hydrogen and carbon combined, are true carbono-hydrous or hydro-carbonous radicals; and, indeed, by adding oxygen, they are convertible into vegetable acids and oxyds, according to their degrees of oxygenation. We cannot, however, affirm, that oils enter in their entire ftate into the compofition of vegetable oxyds, and acids; it is poffible, that they previoufly lofe a part either of their hydrogen and carbon, and that the remaining ingredients no longer exift in the proportions neceffary to conftitute oils. We ftill require farther experiments to elucidate thefe points.

Properly fpeaking, we are only acquainted with one compound radical from the mineral kingdom, the nitro-muriatic, which is formed by the combination of azot with the muriatic radical. The other compound mineral acids have been much lefs attended to, from their producing lefs ftriking phenomena.

SECT. III.—*Obfervations upon the Combination of Light and Caloric with different Subftances.*

I have not conftructed any table of the combinations of light and caloric with the various fimple and compound fubftances, becaufe our conceptions

conceptions of the nature of theſe combinations are not hitherto ſufficiently accurate. We know in general, that all bodies in nature are imbued, ſurrounded, and penetrated in every way with caloric, which fills up every interval left between their particles; that, in certain caſes, caloric becomes fixed in bodies, ſo as to conſtitute a part even of their ſolid ſubſtance, though it more frequently acts upon them with a repulſive force, from which, or from its accumulation in bodies to a greater or leſſer degree, the transformation of ſolids into fluids, and of fluids to aëriform elaſticity, is entirely owing. We have employed the generic name *gas* to indicate this aëriform ſtate of bodies produced by a ſufficient accumulation of caloric; ſo that when we wiſh to expreſs the aëriform ſtate of muriatic acid, carbonic acid, hydrogen, water, alcohol, &c. we do it by adding the word *gas* to their names; thus muriatic acid gas, carbonic acid gas, hydrogen gas, aqueous gas, alcoholic gas, &c.

The combinations of light, and its mode of acting upon different bodies, are ſtill leſs known than thoſe of caloric. By the experiments of Mr Berthollet, it appears to have great affinity with oxygen, is ſuſceptible of combining with it, and contributes along with caloric to change it into the ſtate of gas. Experiments upon vegetation give reaſon to believe that light combines

bines with certain parts of vegetables, and that the green of their leaves, and the various colours of their flowers, are chiefly owing to this combination. This much is certain, that plants which grow in darknefs are perfectly white, languid and unhealthy, and that to make them recover vigour, and to acquire their natural colours, the direct influence of light is abfolutely neceffary. Somewhat fimilar takes place even upon animals: Mankind degenerate to a certain degree when employed in fedentary manufactures, or from living in crowded houfes, or in the narrow lanes of large cities; whereas they improve in their nature and conftitution in moft of the country labours which are carried on in the open air.

Organization, fenfation, fpontaneous motion, and all the operations of life, only exift at the furface of the earth, and in places expofed to the influence of light. Without it nature itfelf would be lifelefs and inanimate. By means of light, the benevolence of the Deity hath filled the furface of the earth with organization, fenfation, and intelligence. The fable of Promotheus might perhaps be confidered as giving a hint of this philofophical truth, which had even prefented itfelf to the knowledge of the ancients.

I have intentionally avoided any difquifitions relative to organized bodies in this work, for which

TABLE of the Binary Combinations of Oxygen with Simple Subſtances.

	Names of the Simple Subſtances.	First degree of oxygenation.		Second degree of oxygenation.		Third degree of oxygenation.		Fourth degree of oxygenation.	
		New Names.	Old Names.	New Names.	Old Names.	New Names.	Old Names.	New Names.	Old Names.
Combinations of oxygen with ſimple non-metallic ſubſtances.	Caloric	Oxygen gas	Vital or dephlogiſticated air						
	Hydrogen	Water *.							
	Azot	Nitrous oxyd, or baſe of nitrous gas	Nitrous gas or air	Nitrous acid	Smoking nitrous acid	Nitric acid	Pale, or not ſmoaking nitrous acid	Oxygenated nitrid acid	Unknown
	Carbon	Oxyd of carbon, or carbonic oxyd	Unknown	Carbonous acid	Unknown	Carbonic acid	Fixed air	Oxygenated carbonic acid	Unknown
	Sulphur	Oxyd of ſulphur	Soft ſulphur	Sulphurous acid	Sulphureous acid	Sulphuric acid	Vitriolic acid	Oxygenated ſulphuric acid	Unknown
	Phoſphorus	Oxyd of phoſphorus	Reſiduum from the combuſtion of phoſphorus	Phoſphorous acid	Volatile acid of phoſphorus	Phoſphoric acid	Phoſphoric acid	Oxygenated phoſporic acid	Unknown
	Muriatic radical	Muriatic oxyd	Unknown	Muriatous acid	Unknown	Muriatic acid	Marine acid	Oxygenated muriatic acid	Dephlogiſticated marine acid
	Fluoric radical	Fluoric oxyd	Unknown	Fluorous acid	Unknown	Fluoric acid	Unknown till lately		
	Boracic radical	Boracic oxyd	Unknown	Boracous acid	Unknown	Boracic acid	Homberg's ſedative ſalt		
Combinations of oxygen with the ſimple metallic ſubſtances †.	Antimony	Grey oxyd of antimony	Grey calx of antimony	White oxyd of antimony	White calx of antimony, diaphoretic antimony	Antimonic acid			
	Silver	Oxyd of ſilver	Calx of ſilver	- - - -	- - - -	Argentic acid			
	Arſenic	Grey oxyd of arſenic	Grey calx of arſenic	White oxyd of arſenic	White calx of arſenic	Arſeniac acid	Acid of arſenic	Oxygenated arſeniac acid	Unknown
	Biſmuth	Grey oxyd of biſmuth	Grey calx of biſmuth	White oxyd of biſmuth	White calx of biſmuth	Biſmuthic acid			
	Cobalt	Grey oxyd of cobalt	Grey calx of cobalt	- - - -	- - - -	Cobaltic acid			
	Copper	Brown oxyd of copper	Brown calx of copper	Blue and green oxyds of copper	Blue and green calces of copper	Cupric acid			
	Tin	Grey oxyd of tin	Grey calx of tin	White oxyd of tin	White calx of tin, or putty of tin	Stannic acid			
	Iron	Black oxyd of iron	Martial ethiops	Yellow and red oxyds of iron	Ochre and ruſt of iron	Ferric acid			
	Manganeſe	Black oxyd of manganeſe	Black calx of manganeſe	White oxyd of manganeſe	White calx of manganeſe	Manganic acid			
	Mercury	Black oxyd of mercury	*Ethiops Mineral* ‡	Yellow and red oxyds of mercury	Turbith mineral, red precipitate, calcined mercury, precipitate *per ſe*	Mercuric acid			
	Molybdena	Oxyd of molybdena	Calx of molybdena	- - - -	- - - -	Molybdic acid	Acid of molybdena	Oxygenated molybdic acid	Unknown
	Nickel	Oxyd of nickel	Calx of nickel	- - - -	- - - -	Nickolic acid			
	Gold	Yellow oxyd of gold	Yellow calx of gold	Red oxyd of gold	Red calx of gold, purple precipitate of Caſſius	Auric acid			
	Platina	Yellow oxyd of platina	Yellow calx of platina	- - - -	- - - -	Platinic acid			
	Lead	Grey oxyd of lead	Grey calx of lead	Yellow and red oxyds of lead	Maſſicot and minium	Plumbic acid			
	Tungſtein	Oxyd of tungſtein	Calx of tungſtein	- - - -	- - - -	Tungſtic acid	Acid of tungſtein	Oxygenated tungſtic acid	Unknown
	Zinc	Grey oxyd of zinc	Grey calx of zinc	White oxyd of zinc	White calx of zinc, pompholix	Zincic acid			

* Only one degree of oxygenation of hydrogen is hitherto known.—A.

† As all the metals, in the oxyd ſtate, are capable of acting in combinations in a ſimilar manner with alkalies and earths, and as the laſt, though diſcovered to be compounds, are, in the new nomenclature, denominated by feminine Latin terms, it would be very convenient to diſtinguiſh the oxyd ſtate of each metal in general, from its reguline ſtate, ſimply by changing the gender; thus Antimoni*um* is the ſimple or reguline ſtate, and Antimoni*a* might indicate the oxyd ſtate in general; any farther diſtinction of the oxyds may be formed as in the table. This propoſed alteration is in perfect conformity with the principles of the new nomenclature, and would ſhorten language without introducing any ambiguity of expreſſion.—T.

‡ Ethiops mineral is the black ſulphuret of mercury; this ſhould have been called, for the old name, black precipitate of mercury.—T.

which reaſon the phenomena of reſpiration, ſanguification, and animal heat, are not conſidered; but I hope, at ſome future time, to be able to elucidate theſe curious ſubjects.

Sect. IV.—*Obſervations upon the Combinations of Oxygen with the ſimple Subſtances.*

Oxygen forms almoſt a third part of the maſs of our atmoſphere, and is conſequently one of the moſt plentiful ſubſtances in nature. All animals and vegetables live and grow in this immenſe magazine of oxygen gas, and from it we procure the greateſt part of what we employ in experiments. So great is the reciprocal affinity between this element and other ſubſtances, that we cannot procure it entirely diſengaged from combination. In the atmoſphere it is united with caloric, in the ſtate of oxygen gas, and this again is mixed with about twice its weight of azotic gas.

Several conditions are requiſite to enable a body to become oxygenated, or to permit oxygen to enter into combination with it. In the firſt place, it is neceſſary that the particles of the body to be oxgenated ſhall have leſs reciprocal attraction with each other than they have for the oxygen, which otherwiſe cannot poſſibly combine with them. Nature, in this caſe, may be aſſiſted by art, as we have it in our power

power to diminiſh the attraction of the particles of bodies, almoſt at will, by heating them, or, in other words, by introducing caloric into the interſtices between their particles; and, as the attraction of theſe particles for each other is diminiſhed in the inverſe ratio of their diſtance, it is evident that there muſt be a certain point of diſtance of particles when the affinity they poſſeſs with each other becomes leſs than that they have for oxygen, and at which oxygenation muſt neceſſarily take place if oxygen be preſent.

We can readily conceive, that the degree of heat at which this phenomenon begins muſt be different in different bodies. Hence, on purpoſe to oxygenate moſt bodies, eſpecially the greater part of the ſimple ſubſtances, it is only neceſſary to expoſe them to the influence of the air of the atmoſphere, in a convenient degree of temperature. With reſpect to lead, mercury, and tin, this requires to be but a little higher than the medium temperature of the earth; but it requires a more conſiderable degree of heat to oxygenate iron, copper, &c. by the dry way, or when this operation is not aſſiſted by moiſture. Sometimes oxygenation takes place with great rapidity, and is accompanied by great ſenſible heat, light and flame; ſuch is the combuſtion of phoſphorus in atmoſpheric air, and of iron in oxygen gas. That of ſulphur is leſs rapid;

rapid; and the oxygenation of lead, tin, and moſt of the metals, takes place vaſtly ſlower, and conſequently the diſengagement of caloric, and more eſpecially of light, is hardly ſenſible.

Some ſubſtances have ſo ſtrong an affinity for oxygen, and combine with it in ſuch low degrees of temperature, that we cannot procure them in their unoxygenated ſtate; ſuch is the muriatic acid, which has not hitherto been decompoſed by art *, perhaps even not by nature, and which conſequently has only been found in the ſtate of acid. It is probable that many other ſubſtances of the mineral kingdom are neceſſarily oxygenated in the common temperature of the atmoſphere; and that, being already ſaturated with oxygen, their farther action upon that element is thereby prevented.

There are other means of oxygenating ſimple ſubſtances, beſides expoſure to air in a certain degree of temperature; ſuch as by placing them in contact with metals combined with oxygen, and which have little affinity with that element. The red oxyd of mercury is one of the beſt ſubſtances for this purpoſe, eſpecially with bodies which do not combine with that metal. In this oxyd the oxygen is united with very little force to

* The real or ſuppoſed diſcovery of the baſe of this acid has been mentioned in ſome former notes.—T.

to the metal, and can be driven out by a degree of heat only ſufficient to make glaſs red hot; wherefore, ſuch bodies as are capable of uniting with oxygen are readily oxygenated, by means of being mixed with red oxyd of mercury, and then moderately heated. The ſame effect may be, to a certain degree, produced by means of the black oxyd of mangaueſe, the red oxyd of lead, the oxyds of ſilver, and by moſt of the metallic oxyds, if we only take care to chooſe ſuch as have leſs affinity with oxygen than the bodies they are meant to oxygenate. All the metallic reductions and revivifications belong to this claſs of operations, being nothing more than oxygenations of carbon, by means of the ſeveral metallic oxyds. The carbon of the charcoal employed for this reduction, combines with the oxygen and with caloric, and eſcapes in form of carbonic acid gas; while the metal remains pure and revivified, or deprived of the oxygen, which before combined with it in the form of oxyd.

All combuſtible ſubſtances may likewiſe be oxygenated by means of mixing them with nitrat of potaſh or of ſoda, or with oxygenated muriat of potaſh, and ſubjecting the mixture to a certain degree of heat; the oxygen, in this caſe, quits the nitrat or the muriat, and combines with the combuſtible body. This ſpecies of oxygenation requires to be performed with extreme

extreme caution, and only with very ſmall quantities; becauſe, as the oxygen enters into the compoſition of nitrat, and more eſpecially of oxygenated muriats, combined with almoſt as much caloric as is neceſſary for converting it into oxygen gas, this immenſe quantity of caloric becomes ſuddenly free, the inſtant of the combination of the oxygen with the combuſtible body, and produces ſuch violent exploſions as are perfectly irreſiſtible.

By the humid way we can oxygenate moſt combuſtible bodies, and convert moſt of the oxyds of the three kingdoms of nature into acids. For this purpoſe we chiefly employ the nitric acid, which has a very ſlight hold of oxygen, and quits it readily to a great number of bodies, by the aſſiſtance of a gentle heat. The oxygenated muriatic acid may be uſed for ſeveral operations of this kind, but not in them all.

I give the name of *binary* to the combinations of oxygen with the ſimple ſubſtances, becauſe in theſe only two elements are combined. When three ſubſtances are united in one combination, I call it *ternary*; and *quaternary* when the combination conſiſts of four ſubſtances united.

TABLE *of the Combinations of Oxygen, with the Compound Radicals.*

Names of the Radicals.	*Names of the resulting Acids.* *New Nomenclature.*	*Old Nomenclature.*
Nitro-muriatic radical	Nitro-muriatic acid	Aqua regia.
*		
Tartaric	Tartarous acid	Unknown till lately.
Malic	Malic acid	Ditto.
Citric	Citric acid	Acid of lemons.
Pyro-lignous	Pyro-lignous acid	Empyreumatic acid of wood.
Pyro-mucous	Pyro-mucous acid.	Empyr. acid of ſugar.
Pyro-tartarous	Pyro-tartarous acid	Empyr. acid of tartar.
Oxalic	Oxalic acid	Acid of ſorrel
Acetic	Acetous acid	Vinegar, or acid of vinegar.
	Acetic acid	Radical vinegar.
Succinic	Succinic acid	Volatile ſalt of amber.
Benzoic	Benzoic acid	Flowers of benzoin.
Camphoric	Camphoric acid	Unknown till lately.
Gallic	Gallic acid	The aſtringent principle of vegetables.
**		
Lactic	Lactic acid	Acid of ſour whey.
Saccholactic	Saccholactic acid	Unknown till lately.
Formic	Formic acid	Acid of ants.
Bombic	Bombic acid	Unknown till lately.
Sebacic	Sebacic acid	Ditto.
Lithic	Lithic acid	Urinary calculus.
Pruſſic	Pruſſic acid	Colouring matter of Pruſſian blue.

SECT.

* Theſe radicals by a firſt degree of oxygenation form vegetable oxyds, as ſugar, ſtarch, mucus, &c.—A.

** Theſe radicals by a firſt degree of oxygenation form the animal oxyds, as lymph, and part of the blood, animal ſecretions, &c.—A.

SECT. V.—*Obſervations upon the Combinations of Oxygen with the Compound Radicals.*

I publiſhed a new theory of the nature and formation of acids in the Memoirs of the Academy for 1776, p. 671. and 1778, p. 535. in which I concluded, that the number of acids muſt be greatly larger than was till then ſuppoſed. Since that time, a new field of inquiry has been opened to chemiſts; and, inſtead of five or ſix acids, which were then known, near thirty new acids have been diſcovered, by which means the number of known neutral ſalts have been increaſed in the ſame proportion. The nature of the acidifiable baſes, or radicals of the acids, and the degrees of oxygenation they are ſuſceptible of, ſtill remain to be inquired into. I have already ſhown, that almoſt all the oxydable and acidifiable radicals from the mineral kingdom are ſimple, and that, on the contrary, there hardly exiſts any radical in the vegetable, and more eſpecially in the animal kingdom, but is compoſed of at leaſt two ſubſtances, hydrogen and carbon, and that azot and phoſphorus are frequently united to theſe, by which we have compound radicals of two, three, and four baſes or ſimple elements united.

From theſe obſervations, it appears, that the vegetable and animal oxyds and acids may differ from each other in three ſeveral ways; according to the number of ſimple acidifiable elements of which their radicals are compoſed; according to the proportions in which theſe are combined together; and according to their different degrees of oxygenation: Theſe circumſtances are more than ſufficient to explain the great variety which nature produces in theſe ſubſtances. It is not at all ſurpriſing, after this, that moſt of the vegetable acids are convertible into each other; nothing more being requiſite for this purpoſe, than to change the proportions of the hydrogen and carbon in their compoſition, and to oxygenate them in a greater or leſſer degree. This has been done by Mr Crell in ſome very ingenious experiments, which have been verified and extended by Mr Haſſenfratz. From theſe it appears, that carbon and hydrogen, by a firſt oxygenation, produce tartarous acid, oxalic acid by a ſecond degree, and acetous or acetic acid by a third, or higher oxygenation; only, that carbon ſeems to exiſt in a rather ſmaller proportion in the acetous and acetic acids. The citric and malic acids differ little from the preceding acids.

Ought we then to conclude, that the oils are the radicals of the vegetable and animal acids? I have already expreſſed my doubts upon this ſubject

ſubject: For, although the oils appear to be formed of nothing but hydrogen and carbon, we do not know if theſe are in the preciſe proportion neceſſary for conſtituting the radicals of the acids; and, ſince oxygen enters into the compoſition of theſe acids equally with hydrogen and carbon, there is no more reaſon for ſuppoſing them to be compoſed of oil rather than of water or of carbonic acid. It is true that they contain the materials neceſſary for all theſe combinations, but then theſe do not take place in the common temperature of the atmoſphere; all the three elements remain combined in a ſtate of equilibrium, which is readily deſtroyed by a temperature only a little above that of boiling water *.

* See Part I. Chap. XII. upon this ſubject.—A.

Table of the Binary Combinations of Azot with the Simple Substances.

Simple Substances.	*Results of the Combinations.* *New Nomenclature.*	*Old Nomenclature.*
Caloric	Azotic gas, or Azogas	Phlogisticated air, or Mephitis.
Hydrogen	Ammoniac, Ammona	Volatile alkali.
Oxygen	Nitrous oxyd	Base of nitrous gas.
	Nitrous acid	Smoaking nitrous acid.
	Nitric acid	Pale nitrous acid.
	Oxygenated nitric acid.	Unknown.
Carbon	This combination is hitherto unknown: should it ever be discovered, it will be called, according to the principles of our nomenclature, Azuret of Carbon. Carbon dissolves in azotic gas, and forms carbonated azotic gas.	
Phosphorus	Azuret of phosphorus.	Still unknown.
Sulphur	Azuret of Sulphur.	Still unknown. We know that sulphur dissolves in azotic gas, forming sulphurated azotic gas.
Compound radicals	Azot combines with carbon and hydrogen, and sometimes with phosphorus, in the compound oxydable and acidifiable bases, and is generally contained in the radicals of the animal acids.	
Metallic substances	Such combinations are hitherto unknown: if ever discovered, they will form metallic azurets, as azurets of gold, of silver, &c.	
Lime, Magnesia, Barytes, Argil, Potash, Soda	Entirely unknown. If ever discovered, they will form azuret of lime, azuret of magnesia, &c.	

Sect.

Note.—The Latin term, in the new nomenclature, here translated Azuret, is *Azuretum*, the French of Mr Lavoisier is Azure; I preferred taking the English from the Latin, because it is thus more

SECT. VI.—*Obſervations upon the Combinations of Azot with the Simple Subſtances.*

Azot is one of the moſt abundant elements: combined with caloric it forms azotic gas, or mephitis, which compoſes nearly two-thirds of the atmoſphere. This element is always in the ſtate of gas in the ordinary preſſure and temperature, and no degree of compreſſion or of cold has been hitherto capable of reducing it either to a ſolid or liquid form. This is likewiſe one of the eſſential conſtituent elements of animal bodies in which it is combined with carbon and hydrogen, and ſometimes with phoſphorus; theſe are united together along with a certain portion of oxygen, by which they are formed into oxyds or acids, according to the degree of oxygenation. Hence the animal ſubſtances may be varied, in the ſame way with vegetables, in three different manners; according to the number of elements which enter into the com-

 poſition

more diſtinct from other [illegible]ns: the French terms Azure, Sulphure, Phoſphure, are not ſufficiently diſtinguiſhable in Engliſh, from Azure, a colour, Sulphur, and Phoſphor, which is ſometimes uſed for Phoſphorus; but Azuret, Sulphuret, Carburet, and Phoſphuret, which are tranſlated from Azuretum, Sulphuretum, Carburetum, and Phoſphoretum, both anſwer the purpoſe of the new nomenclature completely, and run no hazard of occaſioning any miſtake.—T.

pofition of the bafe or radical; according to the proportion of thefe elements; and, according to the degrees of oxygenation.

When combined with oxygen, azot forms the nitrous and nitric oxyds and acids; when with hydrogen, ammoniac is produced. Its combinations with the other fimple elements are very little known; to thefe we give the name of Azurets, preferving the termination in *uret* for all unoxygenated compounds. It is extremely probable that all the alkaline fubftances may hereafter be found to belong to this genus of azurets.

The azotic gas may be procured from atmofpheric air, by abforbing the oxygen gas which is mixed with it by means of a folution of fulphuret of potafh, or fulphuret of lime. It requires twelve or fifteen days to complete this procefs, during which time the furface in contact muft be frequently renewed by agitation, and by breaking the pellicle which forms on the top of the folution. It may likewife be procured by diffolving animal fubftances in dilute nitric acid very little heated. In this operation, the azot is difengaged in form of gas, which muft be received under bell-glaffes filled with water, in the pneumato-chemical apparatus. We may procure this gas, by deflagrating nitre with charcoal, or any other combuftible fubftance; when with charcoal, the azotic gas is mixed

mixed with carbonic acid gas, which may be abſorbed by a ſolution of cauſtic alkali, or by lime-water, after which the azotic gas remains pure. We can procure it in a fourth manner from combinations of ammoniac with metallic oxyds, as pointed out by Mr de Fourcroy: The hydrogen of the ammoniac combines with the oxygen of the oxyd, and forms water, while the azot being left free eſcapes in form of gas.

The combinations of azot were but lately diſcovered: Mr Cavendiſh firſt obſerved it in nitrous gas and acid, and Mr Berthollet in ammoniac and the pruſſic acid. As no evidence of its decompoſition has hitherto appeared, we are fully entitled to conſider azot as a ſimple elementary ſubſtance.

TABLE *of the Binary Combinations of Hydrogen with Simple Substances.*

Simple Subſtances.	*Reſulting Compounds.* *New Nomenclature.*	*Old Names.*
Caloric	Hydrogen gas	Inflammable air.
Azot	Ammoniac	Volatile alkali.
Oxygen	Water	Water.
Sulphur	Hydruret of ſulphur, or ſulphur of hydrogen	Hitherto unknown*.
Phoſphorus	Hydruret of phoſphorus, or phoſpuret of hydrogen	Hitherto unknown*.
Carbon	Hydro-carbonous, or carbono-hydrous radicals †	Not known till late
Mettallic ſubſtances, as iron, &c.	Metallic hydrurets ‡, as hydruret of iron, &c.	Hitherto unknown.

SECT.

* Theſe combinations take place in the ſtate of gas, and form, reſpectively, ſulphurated and phoſphorated hydrogen gas.—A.

† This combination of hydrogen with carbon includes the fixed and volatile oils, and forms the radicals of a conſiderable part of the vegetable and animal oxyds and acids. When it takes place in the ſtate of gas, it forms carbonated hydrogen gas.—A.

‡ None of theſe combinations are known, and it is probable that they cannot exiſt, at leaſt in the uſual temperature of the atmoſphere, owing to the great affinity of hydrogen for caloric.—A.

Sect. VII.—*Obſervations upon Hydrogen, and its Combinations with Simple Subſtances.*

Hydrogen, as its name expreſſes, is one of the conſtituent elements of water, of which it forms fifteen hundredth parts by weight, combined with eighty-five hundredth parts of oxygen. This ſubſtance, the properties and even exiſtence of which was unknown till lately, is very plentifully diſtributed in nature, and acts a very conſiderable part in the proceſſes of the animal and vegetable kingdoms. As it poſſeſſes ſo great affinity with caloric as only to exiſt in the ſtate of gas, it is conſequently impoſſible to procure it in the concrete or liquid ſtate, independent of combination.

To procure hydrogen, or rather hydrogen gas, we have only to ſubject water to the action of a ſubſtance which with oxygen has a greater affinity than it has to hydrogen: by this means the hydrogen is ſet free, and, by uniting with caloric, aſſumes the form of hydrogen gas. Red hot iron is uſually employed for this purpoſe: The iron, during the proceſs, becomes oxydated, and is changed into a ſubſtance reſembling the iron ore from the iſland of Elba. In this ſtate of oxyd it is much leſs attractible by the

the magnet, and diſſolves in acids without effervefcence.

Charcoal, in a red heat, has the ſame power of decompoſing water, by attracting the oxygen from its combination with hydrogen. In this proceſs, carbonic acid gas is formed, and mixes with the hydrogen gas, but is eaſily ſeparated by means of water or alkalies, which abſorb the carbonic acid, and leave the hydrogen gas pure. We may likewiſe obtain hydrogen gas by diſſolving iron or zinc in dilute ſulphuric acid. The two metals decompoſe water very ſlowly, and with great difficulty, when alone, but do it with great eaſe and rapidity when aſſiſted by ſulphuric acid; the hydrogen unites with caloric during the proceſs, and is diſengaged in form of hydrogen gas, while the oxygen of the water unites with the metal in the form of oxyd, which is immediately diſſolved in the acid, forming a ſulphat of iron or of zinc.

Some very diſtinguiſhed chemiſts conſider hydrogen as the *phlogiſton* of Stahl; and as that celebrated chemiſt admitted the exiſtence of phlogiſton in ſulphur, charcoal, metals, &c. they are of courſe obliged to ſuppoſe that hydrogen exiſts in all theſe ſubſtances, though they cannot prove their ſuppoſition; even if they could, it would not avail much, ſince this diſengagement of hydrogen is quite inſufficient to explain the phenomena of calcination and combuſtion.

We

We muſt always recur to the examination of this queſtion, " Are the heat and light, which are diſengaged during the different ſpecies of combuſtion, furniſhed by the burning body, or by the oxygen which combines in all theſe operations?" And certainly the ſuppoſition of hydrogen being diſengaged, throws no light whatever upon this queſtion. Beſides, it belongs to thoſe who make ſuppoſitions to prove them; and, doubtleſs, a doctrine which without any ſuppoſition explains the phenomena as well, and as naturally, as theirs does by ſuppoſition, has at leaſt the advantage of greater ſimplicity *.

TABLE

* Thoſe who wiſh to ſee what has been ſaid upon this great chemical queſtion by Meſſ. de Morveau, Bertholet, De Fourcroy, and myſelf, may conſult our tranſlation of Mr Kirwan's Eſſay on Phlogiſton.—A.

TABLE *of the Binary Combinations of Sulphur with Simple Subſtances.*

Simple Subſtances.	*Resulting Compounds.* *New Nomenclature.*	*Old Nomenclature.*
Caloric	Sulphuric gas	
Oxygen	Oxyd of ſulphur	Soft ſulphur.
	Sulphurous acid	Sulphureous acid.
	Sulphuric acid	Vitriolic acid.
Hydrogen	Sulphuret of hydrogen	Unknown Combinations.
Azot	azot	
Phoſphorus	phoſphorus	
Carbon	carbon	
Antimony	antimony	Crude antimony.
Silver	ſilver	
Arſenic	arſenic	Orpiment, realgar.
Biſmuth	biſmuth	
Cobalt	cobalt	
Copper	copper	Copper pyrites.
Tin	tin	
Iron	iron	Iron pyrites.
Mangaleſe	mangaleſe	
Mercury	mercury	Ethiops mineral, cinnabar.
Molybdena	molybdena	
Nickel	nickel	
Gold	gold	
Platina	platina	
Lead	lead	Galena.
Tungſtein	tungſtein	
Zinc	zinc	Blende.
Potaſh	potaſh	Alkaline liver of ſulphur with fixed vegetable alkali.
Soda	ſoda	Alkaline liver of ſulphur with fixed mineral alkali.
Ammoniac	ammoniac	Volatile liver of ſulphur, ſmoaking liquor of Boyle.
Lime	lime	Calcareous liver of ſulphur.
Magneſia	magneſia	Magneſian liver of ſulphur.
Barytes	barytes	Barytic liv. of ſulph.
Argil	argil	Yet unknown.

SECT.

Sect. VIII.—*Obſervations on Sulphur and its Combinations.*

Sulphur is a combuſtible ſubſtance, having a very great tendency to combination; it is naturally in a ſolid ſtate in the ordinary temperature, and requires a heat ſomewhat higher than that of boiling water to make it liquefy. Sulphur is formed by nature in a conſiderable degree of purity in the neighbourbood of volcanoes; we find it likewiſe, chiefly in the ſtate of ſulphuric acid, combined with argil in aluminous ſchiſtus, with lime in gypſum, &c. From theſe combinations it may be procured in the ſtate of ſulphur, by carrying off its oxygen by means of charcoal in a red heat; carbonic acid is formed, and eſcapes in the ſtate of gas; the ſulphur remains combined with the clay, lime, &c. in the ſtate of ſulphuret, which is decompoſed by acids; the acid unites with the earth into a neutral ſalt, and the ſulphur is precipitated.

TABLE *of the Binary Combinations of Phosphorus with the Simple Substances.*

Simple Substances.	*Resulting Compounds.*
Caloric - -	Phosphoric gas.
Oxygen - -	Oxyd of phosphorus. Phosphorous acid. Phosphoric acid.
Hydrogen - -	Phosphuret of hydrogen.
Azot - -	Phosphuret of azot.
Sulphur - -	Phosphuret of sulphur.
Carbon - -	Phosphuret of carbon.
Metallic Substances	Phosphurets of metals *.
Potash - - Soda - - Ammoniac - Lime - - Barytes - - Magnesia - - Argil - -	Phosphuret of Potash, Soda, &c. †.

SECT.

* Of all these combinations of phosphurus with metals, that with iron only is hitherto known, forming the substance formerly called Siderite; neither is it yet ascertained whether, in this combination, the phosphorus be oxygenated or not.—A.

† These combinations of phosphorus with the alkalies and earths are not yet known; and, from the experiments of Mr Gengembre, they appear to be impossible.—A.

Sect. IX.—*Obſervations on Phoſphorus, and its Combinations.*

Phoſphorus is a ſimple combuſtible ſubſtance, which was unknown to chemiſts till 1667, when it was diſcovered by Brandt, who kept the proceſs ſecret; ſoon after Kunkel found out Brandts method of preparation, and made it public. It has been ever ſince known by the name of Kunkels phoſphorus. It was for a long time procured only from urine; and, though Homberg gave an account of the proceſs in the Memoirs of the Academy for 1692, all the philoſophers of Europe were ſupplied with it from England. It was firſt made in France in 1737, before a committee of the Academy at the Royal Garden. At preſent it is procured in a more commodious and more economical manner from animal bones, which are real calcareous phoſphats, according to the proceſſes of Meſſrs Gahn, Scheele, Rouelle, &c. The bones of adult animals, being calcined to whiteneſs, are pounded, and paſſed through a fine ſilk ſieve; upon the fine powder a quantity of dilute ſulphuric acid is poured, leſs than is ſufficient for diſſolving the whole. This acid unites with the calcareous earth of the bones into a ſulphat of lime, and the phoſphoric acid remains free in the liquor. The liquid is decanted off, and the reſiduum waſhed with

boiling water; this water which has been uſed to waſh out the adhering acid, is joined with what was before decanted off, and the whole is gradually evaporated; the diſſolved ſulphat of lime cryſtallizes in form of ſilky threads, which are removed; and, by continuing the evaporation, we procure the phoſphoric acid, under the appearance of a white pellucid glaſs. When this is powdered, and mixed with one-third its weight of charcoal, we procure very pure phoſphorus, by ſublimation *. The phoſphoric acid, as procured by the above proceſs, is never ſo pure as that obtained by oxygenating pure phoſphorus, either by combuſtion or by means of nitric acid; wherefore this latter ſhould always be employed in experiments of reſearch.

Phoſphorus is found in almoſt all animal ſubſtances, and in ſome plants which give a kind of animal analyſis. In all theſe it is uſually combined

* A very convenient method of procuring phoſphorus from urine has lately been diſcovered. The phoſphoric acid is precipitated by a ſolution of acetite of lead, by means of a double decompoſition; the lead uniting with the phoſphoric acid into an inſoluble ſalt which precipitates, while the acetous acid unites with the alkaline ſubſtances of the urine and remains diſſolved. The phoſphat of lead is then repeatedly waſhed, and is decompoſed by means of muriatic acid; a muriat of lead is formed, which is inſoluble, and the phoſporic acid is found in a liquid ſtate: this is evaporated to dryneſs, and, being diſoxygenated by charcoal, in the uſual manner, a very pure phoſphorus ſublimes.—T.

combined with carbon, hydrogen, and azot, forming very compound radicals, which are, for the moſt part, in the ſtate of oxyds, by a firſt degree of union with oxygen. The diſcovery of Mr Haſſenfratz, of phoſphorus being contained in charcoal, gives reaſon to ſuſpect that it is more common in the vegetable kingdom than has been generally ſuppoſed: It is certain, that by proper proceſſes, it may be procured from every individual of ſome of the families of plants. As no experiment has hitherto given reaſon to ſuſpect, that phoſphorus is a compound body, I have arranged it with the ſimple or elementary ſubſtances. It takes fire at the temperature of 104° of the thermometer.

TABLE *of the Binary Combinations of Carbon.*

Simple Subſtances.	*Resulting Compounds.* *New Nomenclature.*	*Old Names.*
Oxygen	Oxyd of carbon	Unknown *.
	Carbonic acid	Fixed air, chalky acid.
Sulphur	Carburet of ſulphur	Unknown.
Phoſphorus	Carburet of phoſphorus	Unknown.
Azot	Carburet of azot	Unknown.
Hydrogen	Carbono-hydrous radicals	
	Fixed and volatile oils	
Metallic Subſtances	Carburets of the ſeveral metals	Of theſe only the carburets of iron and zinc are known, and were formerly called Plumbago.
Alkalies and earths	Carburet of potaſh, &c.	Unknown.

* From late experiments, it appears that charcoal is an oxyd of carbon.—T.

SECT. X.—*Obſervations upon Carbon, and its Combinations with Simple Subſtances.*

As carbon has not been hitherto decompoſed, it muſt, in the preſent ſtate of our knowledge, be conſidered as a ſimple ſubſtance. By modern experiments, it appears to exiſt ready formed in vegetables; and I have already remarked, that, in theſe, it is combined with hydrogen, ſometimes with azot and phoſphorus, forming compound radicals, which may be changed into oxyds or acids, according to their degrees of oxygenation.

To obtain the carbon * contained in vegetable or animal ſubſtances, we ſubject them to the action of fire, at firſt moderate, and afterwards very ſtrong, on purpoſe to drive off the laſt portions of water, which adhere very obſtinately. For chemical purpoſes, this is uſually done in retorts of ſtone ware or porcelain, into which the wood, or other matter, is introduced, and then placed in a reverberatory furnace, raiſed gradually to its greateſt heat: The heat volatizes, or

* It is neceſſary to repeat, that carbon is uſed to denote the pure ſimple elementary ſubſtance, while charcoal ſignifies that ſubſtance, united with ſome ſmall portions of earth and ſalts, as procured from vegetable and animal bodies by burning, or by diſtillation in a red heat.—T.

or changes into gas, all the parts of the body ſuſceptible of combining with caloric into that form; and the carbon, being more fixed in its nature, remains in the retort, combined with a little earth and ſome fixed ſalts, in the form generally known by the name of charcoal.

In the buſineſs of charring wood, this is done by a leſs expenſive proceſs. The wood is diſpoſed in heaps regularly arranged, and covered with earth, ſo as to prevent the acceſs of any more air than is abſolutely neceſſary for ſupporting the fire, which is kept up till all the water and oil is driven off, after which the fire is extinguiſhed by ſhutting up all the air-holes.

We may analyze charcoal either by combuſtion in air, or rather in oxygen gas, or by means of nitric acid: In either caſe we convert its pure carbon into carbonic acid; and ſometimes a little potaſh and ſome neutral ſalts remain. This analyſis has been hitherto but little attended to by chemiſts; and we are not even certain if potaſh exiſts in charcoal before combuſtion, or whether it be formed by means of ſome unknown combination during that proceſs.

" Charcoal *, purified as above directed, was ſuppoſed to conſiſt almoſt entirely of carbon, in a perfectly pure and uncombined ſtate, 28 parts

* Theſe obſervations on charcoal, diamond, &c. are added in this edition by the Tranſlator.—T.

of which, combined with 72 parts of oxygen, formed 100 parts of carbonic acid. Later experiments, however, have ſhewn, that the pureſt charcoal conſiſts of carbon in a ſtate of oxydation, and that diamond is carbon in a perfect ſtate of purity. By theſe experiments, it appears that 17.8 parts of diamond and 82.1 of oxygen form 100 parts of carbonic acid. Hence the 28 parts of carbon, formerly ſuppoſed to conſtitute the baſis of carbonic acid, contain only 17.9 parts of pure carbon, and 10.1 of oxygen, in 28 parts: or 100 parts of the moſt perfectly purified charcoal conſiſt of 64.3 of carbon, united or oxydated by 35.7 parts of oxygen.

"Plumbago or graphite, uſually called black lead, is carbon leſs oxydated than in the ſtate of charcoal, and containing a ſmall portion of oxyd of iron. What is called incombuſtible coal, the charry reſiduum from animal ſubſtances, and the coak or charcoal produced from mineral coal, are likewiſe compoſed of carbon leſs oxydated than the charcoal of wood."

SECT. XI.—*Obſervations upon the Muriatic, Fluoric, and Boracic Radicals, and their Combinations.*

As the combinations of theſe ſubſtances, either with each other, or with the other combuſ-

tible

tible bodies, are hitherto entirely unknown, we have not attempted to form any table for their nomenclature. We only know that theſe radicals are ſuſceptible of oxygenation, and of forming the muriatic, fluoric, and boracic acids: and that, in the acid ſtate, they enter into a number of combinations, to be afterwards detailed. Chemiſtry has hitherto been unable to diſoxygenate any of them, ſo as to exhibit them in a ſimple ſtate. For this purpoſe, ſome ſubſtance muſt be employed, to which oxygen has a ſtronger affinity than to their radicals, either by means of ſingle affinity, or by double elective attraction. All that is known relative to the origin of the radicals of theſe acids, will be mentioned in the ſections ſet apart for conſidering their combinations with the ſalifiable baſes.

Sect. XII.—*Obſervations upon the Combinations of Metals with each other.*

Before cloſing our account of the ſimple or elementary ſubſtances, it might be ſuppoſed neceſſary to give a table of alloys or combinations of metals with each other; but, as ſuch a table would be both exceedingly voluminous and very unſatisfactory, without going into a ſeries of experiments not yet attempted, I have thought it adviſable to omit it altogether. All that is

neceſſary to be mentioned is, that theſe alloys ſhould be named according to the metal in largeſt proportion in the mixture or combination; thus the term *alloy of gold and ſilver*, or gold alloyed with ſilver, indicates that gold is the predominating metal.

Metallic alloys, like all other combinations, have a point of ſaturation; it would even appear, from the experiments by Mr de la Briche, that they have two perfectly diſtinct degrees of ſaturation.

TABLE

TABLE *of the Combinations of Azot, in the ſtate of Nitrous Acid, with the Saliſiable Baſes, arranged according to the Affinities of theſe Baſes with the Acid.*

Names of the Baſes.	*Names of the Neutral Salts. New Nomenclature.*	*Notes.*
Barytes	Nitrite of barytes.	Theſe ſalts are only known of late, and have received no particular names in the old nomenclature.
Potaſh	potaſh.	
Soda	ſoda.	
Lime	lime.	
Magneſia	magneſia.	
Ammoniac	Ammoniac.	
Argil	argil.	
Oxyd of zinc	zinc.	As metals diſſolve both in nitrous and nitric acids, metallic ſalts muſt of conſequence be formed having different degrees of oxygenation. Thoſe wherein the metal is leaſt oxygenated muſt be called Nitrites, and when more ſo Nitrats; but the limits of this diſtinction are difficultly aſcertainable. The older chemiſts were not acquainted with any of theſe ſalts.
iron	iron.	
manganeſe	manganeſe.	
cobalt	cobalt.	
nickel	nickel.	
lead	lead.	
tin	tin.	
copper	copper.	
biſmuth	biſmuth.	
antimony	antimony.	
arſenic	arſenic.	
mercury	mercury.	
ſilver gold platina	It is extremely probable, that gold, ſilver, and platina, only form nitrats, and cannot ſubſiſt in the ſtate of nitrites.	

TABLE

TABLE *of the Combinations of Azot, completely saturated with Oxygen, in the state of Nitric Acid, with the Salifiable Bases, in the Order of their Affinity with that Acid.*

Bases.	*Names of the resulting Neutral Salts.* *New Nomenclature.*	*Old Nomenclature.*
Barytes	Nitrat of barytes	Nitre, with a base of heavy earth.
Potash	potash	Nitre, saltpetre, Nitre with base of potash.
Soda	soda	Quadrangular nitre, Nitre with base of mineral alkali.
Strontites	strontites	Unknown.
Lime	lime	Calcareous nitre. Nitre with calcareous base, Mother-water of nitre, or of saltpetre.
Magnesia	magnesia	Magnesian nitre, Nitre with base of magnesia.
Ammoniac	ammoniac	Ammoniacal nitre.
Argil	argil	Nitrous allum, Argillaceous nitre, Nitre with base of earth of allum.
Oxyd of zinc	zinc	Nitre of zinc.
iron	iron	Nitre of iron, Martial nitre, Nitrated iron.
manganese	manganese	Nitre of manganese.
cobalt	cobalt	Nitre of cobalt.
nickel	nickel	Nitre of nickel.
lead	lead	Saturnine nitre, Nitre of lead.
tin	tin	Nitre of tin.
copper	copper	Nitre of copper, or of Venus.
bismuth	bismuth	Nitre of bismuth.
antimony	antimony	Nitre of antimony.
arsenic	arsenic	Arsenical nitre.
mercury	mercury	Mercurial nitre.
silver	silver	Nitre of silver, or of luna, Lunar Caustic.
gold	gold	Nitre of gold.
platina	platina	Nitre of platina.

SECT.

Sect. XIII.—*Obſervations upon the Nitrous aud Nitric Acids, and their Combinations.*

The nitrous and nitric acids are procured from a neutral ſalt long known in the arts under the name of *ſaltpetre.* This ſalt is extracted by lixiviation from the rubbiſh of old buildings, from the earth of cellars, ſtables, or barns, and in general of all inhabited places *. In theſe earths the nitric acid is uſually combined with lime and magneſia, ſometimes with potaſh, and rarely with argil. As all theſe ſalts, excepting the nitrat of potaſh, attract the moiſture of the air, and conſequently would be difficultly preſerved, advantage is taken, in the manufactures of ſaltpetre, and in the royal refining houſe, of the greater affinity of the nitric acid to potaſh than theſe other baſes, by which means the lime, magneſia, and argil, are precipitated, and all theſe nitrats are reduced to the nitrat of potaſh, or ſaltpetre.

The nitric acid is procured from this ſalt by means of diſtillation. Three parts of pure ſaltpetre

* Saltpetre is likewiſe procured in large quantities by lixiviating the natural ſoil in ſome parts of Bengal, and of the Ruſſian Ukrain.—T.

petre are decompofed by means of one part of concentrated fulphuric acid, in a retort with Woulfes apparatus, (Pl. IV. Fig. 1.) having its bottles half filled with water, and all its joints carefully luted: the nitrous acid paffes over in form of red vapours furcharged with nitrous gas, or, in other words, not completely faturated with oxygen. Part of the acid condenfes in the recipient, in form of a dark orange red liquid, while the reft combines with the water in the bottles. During the diftillation, a large quantity of oxygen gas efcapes, owing to the greater affinity of oxygen to caloric, in a high temperature, than to nitrous acid, though in the ufual temperature of the atmofphere this affinity is reverfed. It is from the difengagement of oxygen that the nitric acid of the neutral falt is in this operation converted into nitrous acid *. It is brought back to the ftate of nitric acid by heating over a gentle fire, which drives off the fuperabundant nitrous gas, and leaves the nitric acid much diluted with water.

Nitric

* It is evident, that in this operation, there is a very great lofs of nitric acid; as, from the difengagement of oxygen, we cannot poffibly procure near the fame quantity of nitric acid by diftillation, that exifted in the combined ftate in the nitre.—T.

Nitric acid is procurable in a more concentrated ſtate, and with much leſs loſs, by mixing very dry clay with ſaltpetre. This mixture is put into an earthen retort, and diſtilled with a ſtrong fire: the clay combines with the potaſh, for which it has great affinity, and the nitric acid paſſes over, ſlightly impregnated with nitrous gas. This is eaſily diſengaged by heating the acid gently in a retort, a ſmall quantity of nitrous gas paſſes over into the recipient, and very pure concentrated nitric acid remains in the retort.

We have already ſeen, that azot is the nitric radical. If to $20\frac{1}{2}$ parts by weight, of azot, $43\frac{1}{2}$ parts of oxygen be added, 64 parts of nitrous gas are formed; and, if to this we join 36 additional parts of oxygen, 100 parts of nitric acid reſult from the combination. Intermediate quantities of oxygen, between theſe two extremes of oxygenation, produce different ſpecies of nitrous acid; or, in other words, nitric acid leſs or more impregnated with nitrous gas. I aſcertained the above proportions by means of decompoſition; and though I cannot anſwer for their abſolute accuracy, they cannot be far removed from truth. Mr Cavendiſh, who firſt ſhewed by ſynthetic experiments, that azot is the baſe of nitric acid, gives the proportions of azot a little larger than I have done; but, as it is not improbable that he produced the nitrous

acid,

acid, and not the nitric, that circumſtance explains in ſome degree the difference in the reſults of our experiments.

As, in all experiments of a philoſophical nature, the utmoſt poſſible degree of accuracy is required, we muſt procure the nitric acid for experimental purpoſes, from nitre which has been previouſly purified from all foreign matters. If, after diſtillation, any ſulphuric acid is ſuſpected in the nitric acid, it is eaſily ſeparated by dropping in a little nitrat of barytes, ſo long as any precipitation takes place; the ſulphuric acid, from its greater affinity, attracts the barytes, and forms with it an inſoluble neutral ſalt, which falls to the bottom. It may be purified in the ſame manner from muriatic acid, by dropping in a little nitrat of ſilver, ſo long as any precipitation of muriat of ſilver is produced. When theſe two precipitations are finiſhed, diſtil off about ſeven-eights of the acid by a gentle heat, and what comes over is in the moſt perfect degree of purity.

The nitric acid is remarkably prone to combination, and is at the ſame time very eaſily decompoſed. Almoſt all the ſimple ſubſtances, with the exception of gold, ſilver, and platina, rob it leſs or more of oxygen; ſome of them even decompoſe it altogether. It was very anciently known, and its combinations have been more ſtudied by chemiſts than thoſe of any

other

other acid. Theſe combinations were named *nitres* by Meſſrs Macquer and Beaumé; but we have changed their names to nitrats and nitrites, according as they are formed by nitric or by nitrous acid, and have added the ſpecific name of each particular baſe, to diſtinguiſh the ſeveral combinations from each other.

TABLE

TABLE *of the Combinations of Sulphuric Acid with the Salifiable Bases, in the order of Affinity.*

Names of the Bases.	*Resulting Compounds.* New Nomenclature.	*Old Nomenclature.*
Barytes	Sulphat of barytes	Heavy spar, Vitriol of heavy earth.
Strontites	ſtrontites	Unknown.
Potaſh	potaſh	Vitriolated tartar, Sal de duobus, Arcanum duplicatum.
Soda	ſoda	Glaubers ſalt.
Lime	lime	Selenite, gypſum, calcareous vitriol.
Magneſia	magneſia	Epſom ſalt, Sedlitz ſalt, Magneſian vitriol.
Ammoniac	ammoniac	Glaubers ſecret ſal ammoniac.
Argil	argil	Alum.
Oxyd of zinc	zinc	White vitriol, Goſlar vitriol, White coperas, Vitriol of zinc.
iron	iron	Green coperas, Green vitriol, Martial vitriol, Vitriol of iron.
mangaueſe	manganeſe	Vitriol of manganeſe.
cobalt	cobalt	Vitriol of cobalt.
nickel	nickel	Vitriol of nickel.
lead	lead	Vitriol of lead.
tin	tin	Vitriol of tin.
copper	copper	Blue coperas, Blue vitriol, Roman vitriol, Vitriol of copper.
biſmuth	biſmuth	Vitriol of biſmuth.
antimony	antimony	Vitriol of antimony.
arſenic	arſenic	Vitriol of arſenic.
mercury	mercury	Vitriol of mercury.
ſilver	ſilver	Vitriol of ſilver.
gold	gold	Vitriol of gold.
platina	platina	Vitriol of platina.

SECT. XIV.—*Obſervations upon Sulphuric Acid, and its Combinations.*

For a long time this acid was procured by diſtillation from ſulphat of iron, in which ſulphuric acid and oxyd of iron are combined, according to the proceſs deſcribed by Baſil Valentine in the fifteenth century; but, in modern times, it is procured more economically by the combuſtion of ſulphur in proper veſſels. Both to facilitate the combuſtion, and to aſſiſt the oxygenation of the ſulphur, a little powdered ſaltpetre, or nitrat of potaſh, is mixed with it; the nitre is decompoſed, giving out its oxygen to the ſulphur, and contributes to its converſion into an acid. Notwithſtanding this addition, the ſulphur will only continue to burn, in cloſe veſſels, for a limited time, the combination ſoon ceaſes, becauſe the oxygen is exhauſted, and the air of the veſſels is reduced almoſt to pure azotic gas; and becauſe the acid itſelf remains long in the ſtate of vapour, and hinders the progreſs of combuſtion.

In the manufactories for making ſulphuric acid in the large way, the mixture of nitre and ſulphur is burnt in large cloſe-built chambers, lined with lead, having a little water at the bottom, for facilitating the condenſation of the vapours. Afterwards, by diſtillation in large re-

torts with a gentle heat, the water paſſes over, ſlightly impregnated with acid, and the ſulphuric acid remains behind in a concentrated ſtate. It is then pellucid, without any flavour, and nearly double the weight of an equal bulk of water. This proceſs would be greatly facilitated, and the combuſtion much prolonged, by introducing freſh air into the chambers, by means of ſeveral pairs of bellows directed towards the flame of the ſulphur, and by allowing the nitrous gas to eſcape through long ſerpentine canals, in contact with water, to abſorb any ſulphuric or ſulphurous acid gas it might contain.

By one experiment, Mr Berthollet found that 69 parts of ſulphur in combuſtion, united with 31 parts of oxygen, to form 100 parts of ſulphuric acid ; and, by another experiment, made in a different manner, he calculates that 100 parts of ſulphuric acid conſiſt of 72 parts of ſulphur, combined with 28 parts of oxygen, all by weight.

This acid, in common with every other, can only diſſolve metals when they have been previouſly oxydated ; but moſt of the metals are capable of decompoſing a part of the acid, ſo as to carry off a ſufficient quantity of oxygen, to render themſelves ſoluble in the part of the acid which remains undecompoſed. This happens with ſilver, mercury, iron, and zinc, in boiling concentrated ſulphuric acid ; they become

come firſt oxydated by decompoſing part of the acid, and are then diſſolved in the other part; but they do not ſufficiently diſoxygenate the decompoſed part of the acid to reconvert it into ſulphur; it is only reduced to the ſtate of ſulphurous acid, which, being volatilized by the heat, flies off in the form of ſulphurous acid gas.

Silver, mercury, and all the other metals except iron and zinc, are inſoluble in diluted ſulphuric acid, becauſe they have not ſufficient affinity with oxygen to withdraw it from its combination either with the ſulphur, the ſulphurous acid, or the hydrogen; but iron and zinc, being aſſiſted by the action of the acid, decompoſe the water, and become oxydated at its expence, without the help of heat *.

* The hydrogen gas, employed in filling balloons, is chiefly procured by this proceſs of diſſolving iron filings, or borings of iron cannon, in dilute ſulphuric acid. The iron decompoſes the water, forming oxyd of iron with its oxygen, and combines with the ſulphuric acid into ſulphat of iron, while the hydrogen of the water is ſet free in the gaſeous form.—T.

TABLE *of the Combinations of the Sulphurous Acid with the Salifiable Bases, in the order of Affinity.*

Names of the Bases.	*Names of the Neutral Salts.*
Barytes	Sulphite of barytes.
Potash	potash.
Soda	soda.
Lime	lime.
Magnesia	magnesia.
Ammoniac	ammoniac.
Argil	argil.
Oxyd of zinc	zinc.
iron	iron.
manganese	manganese.
cobalt	cobalt.
nickel	nickel.
lead	lead.
tin	tin.
copper	copper.
bismuth	bismuth.
antimony	antimony.
arsenic	arsenic.
mercury	mercury.
silver	silver.
gold	gold.
platina	platina.

SECT.

Note.——The only one of these salts known to the old chemists was the sulphite of Potash, under the name of *Stahls sulphureous salt:* So that, before our new nomenclature, these compounds must have been named *Stahls sulphureous salt*, having base of fixed vegetable alkali; and so of th- rest.

In this Table we have followed Bergmans order of affinity of the sulphuric acid, which is the same in regard to the earths and alkalies, but it is not certain if the order be the same for the metallic oxyds.—A.

Sect. XV.—*Obſervations upon Sulphurous Acid, and its Combinations.*

The ſulphurous acid is formed by the union of oxygen with ſulphur, in a lower degree of oxygenation than the ſulphuric acid. It is procurable either by burning ſulphur ſlowly, or by diſtilling ſulphuric acid from ſilver, antimony, lead, mercury, or charcoal; by theſe operations a part of the oxygen quits the acid, uniting to theſe oxydable baſes, and the acid paſſes over in the ſulphurous ſtate of oxygenation. This acid, in the common preſſure and temperature of the air, can only exiſt in form of gas; but it appears, from the experiments of Mr Clouet, that, in a very low temperature, it condenſes, and becomes fluid. Water abſorbs a great deal more of this gas than of carbonic acid gas, but much leſs than it does of muriatic acid gas.

That the metals cannot be diſſolved in acids without being previouſly oxydated, or by procuring oxygen, for that purpoſe, from the acids during ſolution, is a general and well-eſtabliſhed fact, which I have perhaps repeated too often. Hence, as ſulphurous acid is already deprived of great part of the oxygen neceſſary for forming the ſulphuric acid, it is more diſpoſed to recover oxygen, than to furniſh it to the greateſt part of the metals; and, for this reaſon, it can-

not diſſolve them, unleſs previouſly oxydated by other means. From the ſame principle it is that the metallic oxyds diſſolve without effer-veſcence, and with great facility, in ſulphurous acid. This acid, like the muriatic, has even the property of diſſolving metallic oxyds ſurchar-ged with oxygen, and which are, conſequently, inſoluble in ſulphuric acid, and in this way true ſulphats are formed. Hence we might be led to conclude that there are no metallic ſulphites, were it not that the phenomena which accom-pany the ſolution of iron, mercury, and ſome other metals, convince us that theſe metallic ſubſtances are ſuſceptible of two degrees of oxy-dation, during their ſolution in acids. There-fore the neutral ſalt in which the metal is leaſt oxydated muſt be named *ſulphite*, and that in which it is fully oxydated, muſt be called *ſulphat*. It is yet unknown whether this diſtinction is ap-plicable to any of the metallic ſulphats, except thoſe of iron or mercury.

TABLE

TABLE *of the Combinations of the Phoſphorous and Phoſphoric Acids with the Salifiable Baſes, in the Order of Affinity.*

Names of the Baſes.	*Names of the Neutral Salts formed by* *Phoſphorous Acid.*	*Phoſphoric Acid.*
	Phoſphites of *	Phoſphats of †
Lime	lime	lime.
Strontites	ſtrontites	ſtrontites.
Barytes	barytes	barytes.
Magneſia	magneſia	magneſia.
Potaſh	potaſh	potaſh.
Soda	ſoda	ſoda.
Ammoniac	ammoniac	ammoniac.
Argil	argil	argil.
Oxyds of ‡		
zinc	zinc	zinc.
iron	iron	iron.
mangaueſe	manganeſe	manganeſe.
cobalt	cobalt	cobalt.
nickel	nickel	nickel.
lead	lead	lead.
tin	tin	tin.
copper	copper	copper.
biſmuth	biſmuth	biſmuth.
antimony	antimony	antimony.
arſenic	arſenic	arſenic.
mercury	mercury	mercury.
ſilver	ſilver	ſilver.
gold	gold	gold.
platina	platina	platina.

* All the phoſphites were unknown till lately, and conſequently have not hitherto received names.—A.

† The greater part of the phoſphats were only diſcovered of late, and have not yet been named.—A.

‡ The exiſtence of metallic phoſphites ſuppoſes that metals are ſuſceptible of ſolution in phoſphoric acid at different degrees of oxygenation, which is not yet aſcertained.—A.

Sect. XVI.—*Obſervations upon Phoſphorous and Phoſphoric Acids, and their Combinations.*

Under the article Phoſphorus, Part II. Sect. IX. we have already given a hiſtory of the diſcovery of that ſingular ſubſtance, with ſome obſervations upon the mode of its exiſtence in vegetable and animal bodies. The beſt method of obtaining this acid in a ſtate of purity is by burning well purified phoſphorus under bell-glaſſes, moiſtened on the inſide with diſtilled water; during combuſtion it abſorbs twice and a half its weight of oxygen; ſo that 100 parts of phoſphoric acid is compoſed of 28$\frac{1}{2}$ parts of phoſphorus united to 71$\frac{1}{2}$ parts of oxygen. This acid may be obtained concrete, in form of white flakes, which greedily attract the moiſture of the air, by burning phoſphorus in a dry glaſs over mercury.

To obtain phoſphorous acid, which is phoſphorus leſs oxygenated than in the ſtate of phoſphoric acid, the phoſphorus muſt be burnt by a very ſlow ſpontaneous combuſtion over a glaſs funnel leading into a cryſtal phial; after a few days, the phoſphorus is found oxygenated, and the phoſphorous acid, in proportion as it forms, attracts moiſture from the air, and drops into the phial. The phoſphorous acid is readily changed into phoſphoric acid by expoſure for a long time

to the free air; it abſorbs oxygen from the air, and becomes fully oxygenated.

As phoſphorus has a ſufficient affinity for oxygen to attract it from the nitric and oxygenated muriatic acids, we may form phoſphoric acid, by means of theſe acids, in a very ſimple and cheap manner. Fill a tubulated receiver, half full of concentrated nitric acid, and heat it gently, then throw in ſmall pieces of phoſphorus through the tube, theſe are diſſolved with effervefcence, and red fumes of nitrous gas fly off; add phoſphorus ſo long as it will diſſolve, and then increaſe the fire under the retort, to drive off the laſt particles of nitric acid; phoſphoric acid, partly fluid and partly concrete, remains in the retort.

TABLE *of the Combinations of Carbonic Acid, with the Salifiable Bases, in the Order of Affinity.*

Names of the Bases.	*Resulting Neutral Salts.* *New Nomenclature.*	*Old Nomenclature.*
Barytes	Carbonats of * barytes	Aërated or Effervescent heavy earth.
Lime	lime	Chalk, Calcareous spar, Aërated calcareous earth.
Strontites	strontites	Unknown.
Potash	potash	Effervescing or Aërated fixed vegetable alkali, Mephite of potash.
Soda	soda	Aërated or Effervescing fixed mineral alkali, Mephitic soda.
Magnesia	magnesia	Aërated, effervescing, mild or mephitic magnesia.
Ammoniac	ammoniac	Aërated, effervescing, mild or mephitic, volatile alkali.
Argil	argil	Aërated or effervescing argillaceous earth, or Earth of alum.
Oxyds of zinc	zinc	Zinc spar, Mephitic or aërated zinc.
iron	iron	Sparry iron-ore, Mephitic or aërated iron.
manganese	manganese	Aërated manganese.
cobalt	cobalt	Aërated cobalt.
nickel	nickel	Aërated nickel.
lead	lead	Sparry lead-ore, or Aërated lead.
tin	tin	Aërated tin.
copper	copper	Aërated copper.
bismuth	bismuth	Aërated bismuth.
antimony	antimony	Aërated antimony.
arsenic	arsenic	Aërated arsenic.
mercury	mercury	Aërated mercury.
silver	silver	Aërated silver.
gold	gold	Aërated gold.
platina	platina	Aërated platina.

SECT.

* As these salts have only been understood of late, they have not, properly speaking, any old names. Mr Morveau, in the First Volume of the Encyclopedia, calls them *Mephites*; Mr Bergman gives them the name of *aërated*; and Mr de Fourcroy, who calls the carbonic acid *chalky acid*, gives them the name of *chalks*.—A.

SECT. XVII.—*Obſervations upon Carbonic Acid, and its Combinations.*

Of all the known acids, the carbonic is the moſt abundant in nature; it exiſts ready formed in chalk, marble, and all the calcareous ſtones, in which it is neutralized by a particular earth called *lime*. To diſengage it from this combination, nothing more is requiſite than to add ſome ſulphuric acid, or any other which has a ſtronger affinity for lime; a briſk efferveſcence enſues, which is produced by the diſengaged carbonic acid aſſuming the ſtate of gas, immediately upon being ſet free. This gas, incapable of being condenſed into the ſolid or liquid form by any degree of cold or of preſſure hitherto known, unites to about its own bulk of water, and thereby forms a very weak acid liquor. It may likewiſe be obtained in great abundance from ſaccharine matters in fermentation; but is then contaminated by a ſmall portion of alcohol, which it holds in ſolution.

As carbon is the radical of this acid, we may form it artificially, by burning charcoal in oxygen gas, or by combining charcoal and metallic oxyds in proper proportions; the oxygen of the oxyd combines with the carbon, forming carbonic acid gas, and the metal being left free, recovers its metallic or reguline form.

We are indebted for our firſt knowledge of

this

this acid to Dr Black, before whofe time its property of remaining always in the ftate of gas had enabled it to elude the refearches of chemiftry.

It would be a moft valuable difcovery to fociety, if we could decompofe this gas by any cheap procefs, as by that means we might obtain, for economical purpofes, the immenfe ftore of charcoal contained in calcareous earths, marbles, limeftones, &c. This cannot be effected by fingle affinity, becaufe, to decompofe the carbonic acid, it requires a fubftance as combuftible as charcoal itfelf, fo that we fhould only make an exchange of one combuftible body for another not more valuable; but it may poffibly be accomplifhed * by double affinity, fince this procefs is fo readily performed by Nature, during vegetation, from the moft common materials.

TABLE

* Mr Smithfon Tennant has given, in the Phil. Tranf. for 1791, Art. XI. fome experiments on the decompofition of carbonic acid. Some powdered marble, flightly calcined, and fome phofphorus, being introduced into a glafs-tube coated with a lute of fand and clay, are kept in a red heat for fome minutes, and fuffered to cool; on breaking the tube, a black powder is found, which confifts of charcoal and phofphat of lime. In the laboratory of Dr Black, the decompofition has been produced, *viâ humidâ;* fome folution of fulphuret of potafh, that had ftood for feveral days in an open matrafs, expofed to the air of the room, which had been breathed by feveral hundred ftudents, was found to have depofited charcoal on the fides of the veffel.—T.

TABLE *of the Combinations of Muriatic Acid with the Salifiable Bases, in the Order of Affinity.*

Names of the Bases.	*Resulting Neutral Salts.* *New Nomenclature.*	*Old Nomenclature.*
Barytes	Muriat of barytes	Sea-salt having base of heavy earth.
Potash	potash	Febrifuge salt of Sylvius. Muriated vegetable fixed alkali.
Soda	soda	Sea-salt.
Strontites	strontites	Unknown.
Lime	lime	Muriated lime. Oil of lime.
Magnesia	magnesia	Marine Epsom salt. Muriated magnesia.
Ammoniac	ammoniac	Sal ammoniac.
Argil	argil	Muriated alum, Sea-salt with base of earth of alum.
Oxyd of zinc	zinc	Sea-salt of zinc, or Muriatic zinc.
iron	iron	Salt of iron, or Martial sea-salt.
manganese	manganese	Sea-salt of manganese.
cobalt	cobalt	Sea-salt of cobalt.
nickel	nickel	Sea-salt of nickel.
lead	lead	Horney lead, or Plumbum corneum.
tin	smoaking, of tin	Smoaking liquor of Libavius.
	solid, of tin	Butter of tin.
copper	copper	Sea-salt of copper.
bismuth	bismuth	Sea-salt of bismuth.
antimony	antimony	Sea-salt of antimony.
arsenic	arsenic	Sea-salt of arsenic.
mercury	sweet, of mercury	Sweet sublimate of mercury, Calomel, Aquila alba.
	corrosive, of mercury	Corrosive sublimate of mercury.
silver	silver	Horny silver, Argentum corneum, Luna cornea.
gold	gold	Sea-salt of gold.
platina	platina	Sea-salt of platina.

TABLE

TABLE *of the Combinations of Oxygenated Muriatic Acid with the Salifiable Bases, in the Order of Affinity.*

Names of the Bases.	*Names of the Neutral Salts by the New Nomenclature.*
	Oxygenated muriat * of
Barytes	barytes.
Potash	potash.
Soda	soda.
Lime	lime.
Magnesia	magnesia.
Argil	argil.
Oxyd of	
zinc	zinc.
iron	iron.
manganese	manganese.
cobalt	cobalt.
nickel	nickel.
lead	lead.
tin	tin.
copper	copper.
bismuth	bismuth.
antimony	antimony.
arsenic	arsenic.
mercury	mercury,
silver	silver.
gold	gold.
platina	platina.

SECT.

This order of salts, entirely unknown to the older chemists, was discovered in 1786 by Mr Berthollet.—A.

* The much more convenient term of *Oxymuriat*, is now very generally adopted for this order of combinations.—T.

Sect. XVIII.—*Obſervations upon Muriatic and Oxygenated Muriatic Acids, and their Combinations.*

Muriatic acid is very abundant in the mineral kingdom, naturally combined with different ſalifiable baſes, eſpecially with ſoda, lime, and magneſia. In ſea-water, and the water of ſeveral lakes, it is combined with theſe three baſes; and in mines of rock-ſalt it is chiefly united to ſoda. This acid does not appear to have been hitherto decompoſed in any chemical experiment * ſo that we have no idea whatever of the nature of its radical, and only conclude, from analogy with the other acids, that it contains oxygen as its acidifying principle. Mr Berthollet † ſuſpects the radical to be of a metallic nature; but, as Nature appears to form this acid daily in inhabited places, by combining miaſmata with aëriform fluids, this muſt neceſſarily ſuppoſe a metallic gas to exiſt in the atmoſphere, which is certainly not impoſſible, but cannot be admitted without proof.

The

* This ſubject has been already mentioned in ſome former notes, where the late diſcovery of this baſe is ſaid to have been made by Dr Girtanner.—T.

† He has ſince entertained an idea, but not grounded on deciſive experiments, that its baſis is a compound of hydrogen and azot.—T.

The muriatic acid has only a moderate adherence to the falifiable bafes, and can readily be driven from its combination with thefe by fulphuric acid. Other acids, as the nitric, for inftance, may anfwer the fame purpofe; but nitric acid being volatile, would mix, during diftillation with the muriatic. About one part of fulphuric acid is fufficient to decompofe two parts of decrepitated fea-falt. This operation is performed in a tubulated retort, having Woulfes apparatus, Pl. IV. Fig. 1. adapted to it. When all the junctures are properly luted, the fea-falt is put into the retort, through the tube, the fulphuric acid is poured on, and the opening is immediately clofed by its ground cryftal-ftopper. As the muriatic acid can only fubfift in the gafeous form, in the ordinary temperature, we cannot condenfe it without the prefence of water. Hence the ufe of the water with which the bottles in Woulfes apparatus are half filled; the muriatic acid gas, driven off from the fea-falt in the retort, combines with the water, and forms what the old chemifts called *fmoaking fpirit of falt*, or *Glaubers fpirit of fea-falt*, which we now name *muriatic acid*.

The acid obtained by the above procefs is ftill capable of combining with a further quantity of oxygen, by being diftilled from the oxyds of manganefe, lead or mercury; and the refulting acid, which we name *oxygenated muriatic acid*, can

can only, like the former, exiſt in the gaſeous form, and is abſorbed, but in a much ſmaller quantity, by water. When the impregnation of water with this gas is puſhed beyond a certain point, the ſuperabundant acid precipitates to the bottom of the veſſels in a concrete form. Mr Berthollet has ſhown that this acid is capable of combining with a great number of the ſalifiable baſes. The neutral ſalts, which reſult from this union are ſuſceptible of deflagrating with charcoal, and with many of the metallic ſubſtances; but theſe deflagrations are very violent and dangerous, owing to the great quantity of caloric which the oxygen carries along with it into the compoſition of oxygenated muriatic acid *.

* It has been formerly mentioned, that *Murioxic acid* would be a more convenient term for this acid, than oxygenated muriatic, the one adopted in the new nomenclature by the French chemiſts: In this caſe, the combinations would be named *Murioxats* of barytes, &c.; inſtead of the much longer, and not more evident, terms of oxygenated muriats.

Of late the Britiſh chemiſts have generally called this acid *Oxymuriatic*, and its compounds with ſalifiable baſes *Oxymuriats*.—T.

TABLE *of the Combinations of Nitro-muriatic Acid with the Salifiable Bafes, in the Order of Affinity, fo far as is known.*

Names of the Bafes.	*Names of the Neutral Salts.*
Argil	Nitro-muriat of argil.
Ammoniac	ammoniac.
Oxyd of	
antimony	antimony.
filver	filver.
arfenic	arfenic.
Barytes	barytes.
Oxyd of	
bifmuth	bifmuth.
Lime	lime.
Oxyd of	
cobalt	cobalt.
copper	copper.
tin	tin.
iron	iron.
Magnefia	magnefia.
Oxyd of	
manganefe	manganefe.
mercury	mercury.
molybdena	molybdena.
nickel	nickel.
gold	gold.
platina	platina.
lead	lead.
Potafh	potafh.
Soda	foda.
Oxyd of	
tungftein	tungftein.
zinc	zinc.

SECT.

Note.—Moft of thefe combinations, efpecially thofe with the earths and alkalies, have been little examined, and we are yet to learn whether they form a mixed falt, in which the compound radical remains combined, or if the two acids feparate, to form two diftinct neutral falts.—A.

Sect. XIX.—*Obſervations upon the Nitro-Muriatic * Acid, and its Combinations.*

The nitro-muriatic acid, formerly called *aqua regia*, is formed by a mixture of nitric and muriatic acids. The radicals of theſe two acids combine together, and form a compound baſe, from which an acid is produced, having properties peculiar to itſelf, and diſtinct from thoſe of all other acids, eſpecially the power of diſſolving gold and platina.

In diſſolutions of metals in this acid, as in all other acids, the metals are firſt oxydated by attracting a part of the oxygen from the compound radical. This occaſions a diſengagement of a particular ſpecies of gas not hitherto deſcribed, which may be called *nitro-muriatic gas*; it has a very diſagreeable ſmell, and is fatal to animal life when reſpired; it attacks iron, and cauſes it to ruſt; it is abſorbed in conſiderable quantity by water, which thereby acquires ſome ſlight characters of acidity. I had occaſion to make theſe remarks during a courſe of experiments

 upon

* Azo-muriatic would perhaps anſwer better as a term for this compound acid; Azo-muria having been, in a former note, propoſed as a more convenient name for the baſe than the more lengthened expreſſion of Nitro-muriatic radical.—T.

upon platina, in which I diſſolved a conſiderable quantity of that metal in nitro-muriatic acid.

I at firſt ſuſpected that, in the mixture of nitric and muriatic acids, the latter attracted a part of the oxygen from the former, and became converted into oxygenated muriatic acid, which gave it the property of diſſolving gold; but ſeveral facts remain inexplicable upon this ſuppoſition. Were it ſo, we ſhould be able to diſengage nitrous gas by heating this acid, which however does not ſenſibly happen. From theſe conſiderations, I am led to adopt the opinion of Mr Berthollet, and to conſider nitro-muriatic acid as a ſingle acid, with a compound baſe or radical.

TABLE *of the Combinations of Fluoric Acid with the Salifiable Bafes, in the Order of Affinity.*

Names of the Bafes.	*Names of the Neutral Salts.*
Lime	Fluat of lime *.
Barytes	barytes.
Strontites	ftrontites.
Magnefia	magnefia.
Potafh	potafh.
Soda	foda.
Ammoniac	ammoniac.
Oxyd of	
zinc	zinc.
manganefe	manganefe.
iron	iron.
lead	lead.
tin	tin.
cobalt	cobalt.
copper	copper.
nickel	nickel.
arfenic	arfenic.
bifmuth	bifmuth.
mercury	mercury.
filver	filver.
gold	gold.
platina	platina.
And, by the dry way,	
Argil	Fluat of argil.

Note.—Thefe combinations were entirely unknown to the old chemifts, and confequently have no names in the old nomenclature.—A.

* Fluor fpar, or Vitreous fpar.

Sect. XX.—*Obſervations upon the Fluoric Acid, and its Combinations.*

Fluoric acid exiſts ready formed by Nature, in the fluoric ſpars *, combined with calcareous earth, ſo as to form an inſoluble neutral ſalt. To obtain it, diſengaged from that combination, fluor ſpar, or fluat of lime, is put into a leaden retort, with a proper quantity of ſulphuric acid; a recipient, likewiſe of lead, half full of water, is adapted, and fire is applied to the retort. The ſulphuric acid, from its greater affinity, expels the fluoric acid, which paſſes over and is abſorbed by the water in the receiver. As fluoric acid is naturally in the gaſeous form in the ordinary temperature, we can receive it in a pneumato-chemical apparatus over mercury. We are obliged to employ metallic veſſels in this proceſs, becauſe fluoric acid diſſolves glaſs and ſiliceous earth, and even renders theſe bodies volatile, carrying them over with itſelf in diſtillation in the gaſeous form.

We are indebted to Mr Margraff for our firſt acquaintance with this acid; though, as he could never

* The beautiful ſpars from Derbyſhire are of this kind.—T.

never procure it free from combination with a confiderable quantity of filiceous earth, he was ignorant of its being an acid fui generis. The Duke de Liancourt, under the name of Mr Boulanger, has confiderably increafed our knowledge of its properties; and Mr Scheele feems to have exhaufted the fubject. The only thing remaining is to endeavour to difcover the nature of the fluoric radical, of which we cannot hitherto form any idea, as the acid does not appear to have been decompofed in any experiment. It is only by means of compound affinity that experiments ought to be made with this view, with any probability of fuccefs.

TABLE *of the Combinations of Boracic Acid with the Salifiable Bafes, in the Order of Affinity.*

Bafes.	*Neutral Salts.*
Lime *.	Borat of lime.
Barytes	barytes.
Strontites	ftrontites.
Magnefia	magnefia.
Potafh	potafh.
Soda	foda.
Ammoniac	ammoniac.
Oxyd of	
zinc	zinc.
iron	iron.
lead	lead.
tin	tin.
cobalt	cobalt.
copper	copper.
nickel	nickel.
mercury	mercury.
Argil	argil.

SECT.

Note.—Moft of thefe combinations were neither known, nor named by the old chemifts. The boracic acid was formerly called *fedative fal*, and its compounds *borax*, with bafe of fixed vegetable alkali, &c.—A.

* By Dr Hopes experiments, in his paper on ftrontites, read to the Royal Society of Edinburgh, lime follows barytes, and the fuperiority between lime and ftrontites is uncertain.—T.

SECT. XXI.—*Obſervations upon Boracic Acid, and its Combinations.*

This is a concrete acid, extracted from a ſalt procured in India, called *borax* or *tincall.* Although borax has been very long employed in the arts, we have as yet very imperfect knowledge of its origin, and of the methods by which it is extracted and purified; there is reaſon to believe it to be a native ſalt, found in the earth, in certain parts of the eaſt, and in the water of ſome lakes. The whole trade of borax is in the hands of the Dutch, who have been excluſively poſſeſſed of the art of purifying it, till very lately, that Meſſrs L'Eguillier of Paris have rivalled them in the manufacture; but the proceſs ſtill remains a ſecret to the world.

By chemical analyſis, we learn that borax is a neutral ſalt with exceſs of baſe, conſiſting of ſoda, partly ſaturated with a peculiar acid, long called *Hombergs ſedative ſalt,* now *the boracic acid.* This acid is found in an uncombined ſtate in the waters of certain lakes: That of Cherchiais in Italy contains $94\frac{1}{2}$ grains in each pint of water.

To obtain boracic acid, diſſolve ſome borax in boiling water, filtrate the ſolution, and add ſulphuric

ſulphuric acid, or any other having greater affinity to ſoda than the boracic acid; this latter acid is ſeparated, and is procured in a cryſtalline form by cooling. This acid was long conſidered as being formed during the proceſs by which it is obtained, and was conſequently ſuppoſed to differ according to the nature of the acid employed in ſeparating it from the ſoda; but it is now univerſally acknowledged that it is identically the ſame acid, in whatever way procured, provided it be properly purified from mixture of other acids, by waſhing, and by repeated ſolution and cryſtallization. It is ſoluble both in water and alcohol, and has the property of communicating a green colour to the flame of that ſpirit. This circumſtance led to a ſuſpicion of its containing copper, which is not confirmed by any deciſive experiment: On the contrary, if it contain any of that metal, it muſt only be conſidered as an accidental mixture. It combines with the ſalifiable baſes in the humid way; and though, in this manner, it is incapable of diſſolving any of the metals directly, this combination is readily affected by compound affinity.

The Table preſents its combinations in the order of affinity in the humid way; but there is a conſiderable change in the order, when we operate viâ ſiccâ; for, in that caſe, argil, though

though the laſt in our liſt, muſt be placed immediately after ſoda.

The boracic radical is hitherto unknown, no experiments having as yet been able to decompoſe the acid; but we conclude, from analogy with the other acids, that oxygen exiſts in its compoſition, as the acidifying principle.

TABLE

TABLE *of the Combinations of Arſeniac Acid with the Salifiable Baſes, in the Order of Affinity.*

Baſes.	*Neutral Salts.*
Lime	Arſeniat of lime.
Barytes	barytes.
Strontites	ſtrontites.
Magneſia	magneſia.
Potaſh	potaſh.
Soda	ſoda.
Ammoniac	ammoniac.
Oxyd of	
zinc	zinc.
mangancſe	mangancſe.
iron	iron.
lead	lead.
tin	tin.
cobalt	cobalt.
copper	copper.
nickel	nickel.
biſmuth	biſmuth.
mercury	mercury.
antimony	antimony.
ſilver	ſilver.
gold	gold.
platina	platina.
Argil	argil.

SECT.

Note.—This order of ſalts was entirely unknown to the old chemiſts. Mr Macquer, in 1746, diſcovered the combinations of arſeniac acid with potaſh and ſoda, to which he gave the name of *arſenical neutral ſalts.*—A.

Sect. XXII.—*Obſervations upon Arſeniac Acid, and its Combinations.*

In the Collections of the Academy for 1746, Mr Macquer ſhews, that when a mixture of white oxyd of arſenic and nitre are ſubjected to the action of a ſtrong fire, a neutral ſalt is obtained, which he calls *neutral ſalt of arſenic*. At that time, the cauſe of this ſingular phenomenon, in which a metal acts the part of an acid, was quite unknown; but more modern experiments teach, that during this proceſs, the arſenic becomes oxygenated, by carrying off the oxygen of the nitric acid; it is thus converted into a real acid, and combines with the potaſh. There are other methods now known for oxygenating arſenic, and obtaining its acid free from combination. The moſt ſimple and moſt effectual of theſe is as follows: Diſſolve white oxyd of arſenic in three parts, by weight, of muriatic acid; to this ſolution, in a boiling ſtate, add two parts of nitric acid, and evaporate to dryneſs. In this proceſs the nitric acid is decompoſed, its oxygen unites with the oxyd of arſenic, and converts it into an acid, and the nitrous radical flies off in the ſtate of nitrous gas; while the muriatic acid is converted by the heat into muriatic acid gas, and may

may be collected in proper veſſels. The arſenaic acid is entirely freed from the other acids employed during the proceſs by heating it in a crucible till it begins to grow red; what remains is pure concrete arſeniac acid.

Mr Scheeles proceſs, which was repeated with great ſucceſs by Mr Morveau, in the laboratory at Dijon, is as follows: Diſtil muriatic acid from the black oxyd of manganeſe; this converts it into oxygenated muriatic acid, by carrying off the oxygen from the manganeſe; receive this oxygenated acid in a recipient, containing white oxyd of arſenic, covered by a little diſtilled water; the arſenic decompoſes the oxygenated muriatic acid, by carrying off its ſuperſaturation of oxygen, and is converted into arſeniac acid, while the oxygenated muriatic acid is brought back to the ſtate of common muriatic acid. The two acids are ſeparated by diſtillation, with a gentle heat increaſed towards the end of the operation; the muriatic acid paſſes over, and the arſeniac acid remains behind in a white concrete form.

The arſeniac acid is conſiderably leſs volatile than white oxyd of arſenic; it often contains white oxyd of arſenic in ſolution, owing to its not being ſufficiently oxygenated; this is prevented by continuing to add nitrous acid, as in the former proceſs, till no more nitrous gas is produced. From all theſe obſervations, I would

would give the following definition of arseniac acid. It is a white concrete metallic acid, formed by the combination of arsenic with oxygen; it is fixed in a red heat, is soluble in water, and is capable of combining with many of the salifiable bases.

Sect. XXIII.—*Observations upon Molybdic Acid, and its combinations with Acidifiable Bases* *.

Molybdena is a particular metallic body, capable of being oxygenated, so far as to become a true concrete acid †. For this purpose, one part by weight of the ore of molybdena, which is a natural sulphuret of that metal, is put into a retort, with five or six parts of nitric acid, diluted with a quarter of its weight of water, and heat is applied to the retort; the oxygen of the nitric acid acts both upon the molybdena and the sulphur, converting the one into molybdic, and the other into sulphuric acid; pour on fresh quantities of nitric acid so long as any red fumes of

* I have not added the Table of these combinations, as the order of their affinity is entirely unknown; they are called *molybdats of argil, antimony, potash*, &c.—T.

† This acid was discovered by Mr Scheele, to whom chemistry is indebted for the discovery of several other acids.—A.

of nitrous gas efcape; the molybdena is then oxygenated as far as is poffible, and is found at the bottom of the retort in a pulverulent form, refembling chalk. It muft be wafhed in warm water, to feparate any adhering particles of fulphuric acid; and, as it is hardly foluble, we lofe very little of it in this operation. All its combinations with falifiable bafes were unknown to the old chemifts *.

TABLE

* Meffrs Tondi and Ruprecht have lately reduced Molybdena to the reguline ftate, by a fimilar procefs to that formerly defcribed for reducing the metals of Chalk, Magnefia and Barytes. They defcribe the metallic button as being convex and compact, and refembling fteel in its colour; its fracture is uneven and granulated, and has more metallic luftre internally than on the furface; it is brittle, not hard, and not attractible by the magnet. On the furface of one of the buttons procured in thefe experiments, fome little cavities were obferved, in which the metal had cryftallized in form of prifmatic needles, which were too fmall to allow of their particular configuration being accurately determined. The fpecific gravity of this metal, according to the experiments of Mr Haidinger, counfellor of the Schemnitz mines, is 6.963, water being taken as 1.000.—T.

TABLE *of the Combinations of Tungſtic Acid with the Salifiable Baſes.*

Baſes.	*Neutral Salts.*
Lime	Tungſtat of lime.
Barytes	barytes.
Magneſia	magneſia.
Potaſh	potaſh.
Soda	ſoda.
Ammoniac	ammoniac.
Argil	argil.
Oxyd of antimony *, &c.	antimony †, &c.

SECT. XXIV.—*Obſervations upon Tungſtic Acid, and its Combinations.*

Tungſtein is a particular metal, the ore of which has frequently been confounded with that of tin. The ſpecific gravity of this ore is to water as 6 to 1; in its form of cryſtallization it reſembles the garnet, and varies in colour from

* The combinations with metallic oxyds are ſet down by Mr Lavoiſier in alphabetical order, their order of affinity being unknown; I have omitted them as ſerving no purpoſe.—T.

† All theſe ſalts were unknown to the old chemiſts. —A.

from a pearl-white to a yellow and reddiſh; it is found in ſeveral parts of Saxony and Bohemia. The mineral called *Wolfram*, which is frequent in the mines of Cornwall, is likewiſe an ore of this metal. In all theſe ores the metal is oxydated; and, in ſome of them, it appears even to be oxygenated to the ſtate of acid, being combined with lime into a true tungſtat of lime.

To obtain the acid free, mix one part of ore of tungſtein with four parts of carbonat of potaſh, and melt the mixture in a crucible; then powder it and pour on twelve parts of boiling water, add nitric acid, and the tungſtic acid precipitates in a concrete form. Afterwards, to inſure the complete oxygenation of the metal, add more nitric acid, and evaporate to dryneſs, repeating the operation ſo long as red fumes of nitrous gas are produced. To procure tungſtic acid perfectly pure, the fuſion of the ore with carbonat of potaſh muſt be made in a crucible of platina, otherwiſe the earth of the common crucibles will mix with the products, and adulterate the acid.

TABLE *of the Combinations of Tartarous Acid with the Salifiable Bases, in the Order of Affinity.*

Bases.	*Neutral Salts.*
Lime	Tartarite of lime.
Barytes	barytes.
Strontites	ſtrontites.
Magneſia	magneſia.
Potaſh	potaſh.
Soda	ſoda.
Ammoniac	ammoniac.
Argil	argil.
Oxyd of	
zinc	zinc.
iron	iron.
mangaueſe	manganeſe.
cobalt	cobalt.
nickel	nickel.
lead	lead.
tin	tin.
copper	copper.
biſmuth	biſmuth.
antimony	antimony.
arſenic	arſenic.
ſilver	ſilver.
mercury	mercury.
gold	gold.
platina	platina.

Sect. XXV.—*Obſervations upon Tartarous Acid, and its combinations.*

Tartar, or the concretion which fixes to the inſide of veſſels in which the fermentation of wine is completed, is a well-known ſalt, compoſed of a peculiar acid, united, in conſiderable exceſs, to potaſh. Mr Scheele firſt pointed out the method of obtaining this acid pure: Having obſerved that it has a greater affinity to lime than to potaſh, he directs us to proceed in the following manner. Diſſolve purified tartar in boiling water, and add a ſufficient quantity of lime till the acid be completely ſaturated. The tartarite of lime, which is thus formed, being almoſt inſoluble in cold water, falls to the bottom, and is ſeparated from the ſolution of potaſh by decantation; it is afterwards waſhed in cold water, and dried; then ſome ſulphuric acid, diluted with eight or nine parts of water, is poured on; digeſt for twelve hours in a gentle heat, frequently ſtirring the mixture, and the ſulphuric acid combines with the lime, leaving the tartarous acid free. A ſmall quantity of gas, not hitherto examined, is diſengaged during this proceſs. At the end of twelve hours, having decanted off the clear liquor, waſh the ſulphat of lime in cold water, which add to the decanted liquor, then evaporate the whole, and the

the tartarous acid is obtained in a concrete form. Two pounds of purified tartar, by means of from eight to ten ounces of ſulphuric acid, yield about eleven ounces of tartarous acid.

As the combuſtible radical exiſts in exceſs, or as the acid from tartar is not fully ſaturated with oxygen, we call it *tartarous acid*, and the neutral ſalts, formed by its combinations with ſalifiable baſes, are named *tartarites*. The baſe of the tartarous acid is a carbono-hydrous or hydro-carbonous radical, leſs oxygenated than in the oxalic acid; and it would appear, from the experiments of Mr Haſſenfratz, that azot enters into the compoſition of the tartarous radical, even in conſiderable quantity. By oxygenating tartarous acid ſtill farther, it is convertible into oxalic, malic, and acetous acids; but it is probable the proportions of hydrogen and carbon in the radical are changed during theſe converſions, and that the difference between theſe acids does not alone conſiſt in the different degrees of oxygenation.

The tartarous acid is ſuſceptible of two degrees of ſaturation in its combinations with the fixed alkalies; by one of theſe a ſalt is formed with exceſs of acid, improperly called *cream of tartar*, which in our new nomenclature is named *acidulous tartarite of potaſh*; by a ſecond or reciprocal degree of ſaturation, a perfectly neutral ſalt is formed, formerly called *vegetable*

 ſalt,

ſalt, which we name *tarta ite of potaſh.* With ſoda this acid forms tartarite of ſoda, formerly called *ſal de Seignette*, or *ſal polychreſt of Rochell**.

Sect. XXVI.—*Obſervations upon Malic Acid, and its Combinations with the Salifiable Baſes* †.

The malic acid exiſts ready formed in the ſour juice of ripe and unripe apples, and many other fruits, and is obtained as follows: Saturate the juice of apples with potaſh or ſoda, and add a proper proportion of acetite of lead diſſolved in water; a double decompoſition takes place, the malic acid combines with the oxyd of lead, and precipitates, being almoſt inſoluble and the acetite of potaſh or ſoda remains in the liquor. The malat of lead being ſeparated by decantation, is waſhed with cold water, and ſome dilute ſulphuric acid is added; this unites with the lead into an inſoluble ſulphat, and the malic acid remains free in the liquor.

This

* This account of the compoſition of Rochell ſalt is not quite accurate: It is a triple ſalt, conſiſting of tartarous acid ſaturated by ſoda and potaſh, and is formed by completely neutralizing acidulous tartarite of potaſh, by the addition of a ſufficient quantity of ſoda.—T.

† I have omitted the Table, as the order of affinity is unknown, and is given by Mr Lavoiſier only in alphabetical order. All the combinations of malic acid with ſalifiable baſes, which are named *malats*, were unknown to the old chemiſts.—T.

This acid, which is found mixed with citric and tartarous acid in a great number of fruits, is a kind of medium between the oxalic and acetous acids being more oxygenated than the former, and leſs ſo than the latter. From this circumſtance, Mr Hermbſtadt calls it *imperfect vinegar;* but it differs likewiſe from acetous acid, by having rather more carbon, and leſs hydrogen, in the compoſition of its radical.

When an acid much diluted has been uſed in the foregoing proceſs, the liquor contains oxalic as well as malic acid, and probably a little tartarous; theſe are ſeparated by mixing lime-water with the acids, oxalat, tartarite, and malat of lime are produced; the two former, being inſoluble, are precipitated, and the malat of lime remains diſſolved; from this the pure malic acid is ſeparated by the acetite of lead, and afterwards by ſulphuric acid, as directed above.

TABLE *of the Combinations of Citric Acid with the Salifiable Bafes, in the Order of Affinity* *.

Bafes.	*Neutral Salts.*
Barytes	Citrat of barytes,
Lime	lime.
Magnefia	magnefia.
Potafh	potafh.
Soda	foda.
Ammoniac	ammoniac.
Oxyd of	
zinc	zinc.
manganefe	manganefe,
iron	iron.
lead	lead.
cobalt	cobalt.
copper	copper.
arfenic	arfenic.
mercury	mercury.
antimony	antimony.
filver	filver.
gold	gold.
platina	platina.
Argil	argil.

SECT.

* Thefe combinations were unknown to the old chemifts. The order of affinity of the falifiable bafes with this acid was determined by Mr Bergman, and by Mr de Breney of the Dijon Academy.—A.

SECT. XXVII.—*Obſervations upon Citric Acid, and its Combinations.*

The citric acid is procured by expreſſion from lemons, and is found in the juices of many other fruits mixed with malic acid. To obtain it pure and concentrated, it is firſt allowed to depurate from the mucous part of the fruit, by long reſt in a cool cellar, and is afterwards concentrated by expoſing it to the temperature of from 21° to 23° of Fahrenheit; the water is thereby frozen, and the acid remains liquid, reduced to about an eighth part of its original bulk. A lower degree of cold would occaſion the acid to be engaged among the ice, and render it difficultly ſeparated. This proceſs was pointed out by Mr Georgius.

It is more eaſily obtained by ſaturating the lemon-juice with lime, ſo as to form a citrat of lime, which is inſoluble in water; waſh this ſalt, and pour on a proper quantity of ſulphuric acid; this forms a ſulphat of lime, which precipitates and leaves the citric acid free in the liquor.

TABLE

TABLE *of the Combinations of Pyro-lignous Acid with the Salifiable Bases, in the Order of Affinity* *.

Bases.	*Neutral Salts.*
Lime	Pyro-lignite of lime.
Barytes	barytes.
Potash	potash.
Soda	soda.
Magnesia	magnesia.
Ammoniac	ammoniac.
Oxyd of	
zinc	zinc.
manganese	manganese.
iron	iron.
lead	lead.
tin	tin.
cobalt	cobalt.
copper	copper.
nickel	nickel.
arsenic	arsenic.
bismuth	bismuth.
mercury	mercury.
antimony	antimony.
silver	silver.
gold	gold.
platina	platina.
Argil	argil.

SECT.

* The above affinities were determined by Messrs de Morveau and Eloi Boursier de Clervaux. These combinations were entirely unknown till lately.—A.

Sect. XXVIII.—*Observations upon the Pyro-lignous Acid, and its Combinations.*

The old chemists observed that most of the woods, especially the more heavy and compact ones, give out a particular acid spirit, by distillation in a naked fire; but, before Mr Goetling, who gives an account of his experiments upon this subject in Crells Chemical Journal for 1779, no one had ever made any inquiry into its nature and properties. This acid appears to be the same, whatever be the wood it is procured from. When first distilled, it is of a brown colour, and considerably impregnated with carbon and oil; it is purified from these by a second distillation. The pyro-lignous radical is chiefly composed of hydrogen and carbon.

Sect. XXIX.—*Observations upon Pyro-tartarous Acid, and its Combinations with the Salifiable Bases* *.

The name of *Pyro-tartarous Acid* is given to a dilute empyreumatic acid obtained from purified

* The order of affinity of the salifiable bases with this acid is hitherto unknown. Mr Lavoisier, from its similarity

fied acidulous tartarite of potaſh, by diſtillation in a naked fire. To obtain it, let a retort be half-filled with powdered tartar, adapt a tubulated recipient, having a bent tube communicating with a bell-glaſs in a pneumato-chemical apparatus; by gradually raiſing the fire under the retort, we obtain the pyro-tartarous acid mixed with oil, which is ſeparated by means of a funnel. A vaſt quantity of carbonic acid gas is diſengaged during the diſtillation. The acid obtained by the above proceſs is much contaminated with oil, which ought to be ſeparated from it. Some authors adviſe to do this by a ſecond diſtillation; but the Dijon academicians inform us, that this is attended with great danger, from exploſions which take place during the proceſs.

TABLE

rity to pyro-lignous acid, ſuppoſes the order to be the ſame in both; but, as this is not aſcertained by experiment, the table is omitted. All theſe combinations, called *Pyro-tartarites*, were unknown till lately.—T.

TABLE *of the Combinations of Pyro-mucous Acid with the Salifiable Bases, in the Order of Affinity* *.

Bases.	*Neutral Salts.*
Potash	Pyro-mucite of Potash.
Soda	soda.
Barytes	barytes.
Lime	lime.
Magnesia	magnesia.
Ammoniac	ammoniac.
Argil	argil.
Oxyd of	
zinc	zinc.
manganese	manganese.
iron	iron.
lead	lead.
tin	tin.
cobalt	cobalt.
copper	copper.
nickel	nickel.
arsenic	arsenic.
bismuth	bismuth.
antimony	antimony.

SECT.

* All these combinations were unknown to the old chemists.—A.

Sect. XXX. — *Obſervations upon Pyro-mucous Acid, and its Combinations* *.

This acid is obtained by diſtillation in a naked fire from ſugar, and all the ſaccharine bodies; and, as theſe ſubſtances ſwell greatly in the fire, it is neceſſary to leave ſeven-eights of the retort empty. It is of a yellow colour, verging to red, and leaves a mark upon the ſkin, which will not remove but along with the epidermis. It may be procured leſs coloured, by means of a ſecond diſtillation, and is concentrated by freezing, as is directed for the citric acid. It is chiefly compoſed of water and oil, ſlightly oxygenated, and is convertible into oxalic and malic acids, by farther oxygenation with the nitric acid.

It has been pretended that a large quantity of gas is diſengaged during the diſtillation of this acid, which is not the caſe if it be conducted ſlowly, by means of moderate heat.

Table

* We are told that this acid, and the pyro-lignous and pyro-tartarous acids, have lately been aſcertained to be only the acetic acid diſguiſed by the admixture of empyreumatic oil.—T.

TABLE *of the Combinations of the Oxalic Acid with the Salifiable Bases, in the Order of Affinity**.

Bases.	*Neutral Salts.*
Lime	Oxalat of lime.
Barytes	barytes.
Strontites	strontites.
Magnesia	magnesia.
Potash	potash.
Soda	soda.
Ammoniac	ammoniac.
Argil	argil.
Oxyd of	
zinc	zinc.
iron	iron.
manganese	manganese.
cobalt	cobalt.
nickel	nickel.
lead	lead.
copper	copper.
bismuth	bismuth.
antimony	antimony.
arsenic	arsenic.
mercury	mercury.
silver	silver.
gold	gold.
platina	platina.

SECT.

* All unknown to the old chemists.—A.

Sect. XXXI.—*Obſervations upon Oxalic Acid, and its Combinations.*

The oxalic acid is moſtly prepared in Switzerland and Germany from the expreſſed juice of ſorrel, from which it cryſtallizes by being left long at reſt; in this ſtate it is partly ſaturated with potaſh, forming a true acidulous oxalat of potaſh, or ſalt with exceſs of acid. To obtain it pure, it muſt be formed artificially by oxygenating ſugar, which ſeems to be the true oxalic radical. Upon one part of ſugar pour ſix or eight parts of nitric acid, and apply a gentle heat; a conſiderable effervеſcence takes place, and a great quantity of nitrous gas is diſengaged; the nitric acid is decompoſed, and its oxygen unites to the ſugar: by allowing the liquor to ſtand at reſt, cryſtals of pure oxalic acid are formed, which muſt be dried upon blotting paper, to ſeparate any remaining portions of nitric acid; and, to inſure the purity of the acid, diſſolve the cryſtals in diſtilled water, and cryſtallize them afreſh.

From the liquor remaining after the firſt cryſtallization of the oxalic acid we may obtain malic acid by refrigeration: This acid is more oxygenated than the oxalic; and by a further oxygenation,

TABLE of the Comfinity.

Bafes.	*Neutral Sa*	*Nomenclature.*
Barytes - -	Acetite of bary	rveau, who calls it
		i, of Bafil Valentin
Potafh - -	——— pota	oëder. Effentiai falt nius. Diuretic falt,
Soda - - -	——— foda	cryftallizable foliated
Lime - - -	——— lim	an.
Magnefia -	——— mag	
Ammoniac -	——— amr	
Oxyd of zinc -	——— zinc	Laffone, and Wenzel,
——— manganefe	——— mar	
——— iron -	——— iron	e Duke d'Ayen.
——— lead -	——— lead	
——— tin - -	——— tin	id Wenzel, but not
——— cobalt -	——— cob	
——— copper -	——— cop	is, cryftals of Venus
——— nickel -	——— nicl	
——— arfenic -	——— arfe	Mr Cadet.
——— bifmuth	——— bifm	, Pott, Weflendorff,
		remedy. Mentioned
——— mercury	——— me	aumé, Bergman, and
——— antimony	——— anti	
——— filver -	——— filv	to the old chemifts.
——— gold -	——— gol	
——— platina -	——— plat	
Argil - - -	——— arg	proportion of argil.

oxygenation, the ſugar is convertible into acetous acid, or vinegar.

The oxalic acid, combined with a ſmall quantity of ſoda or potaſh, has the property, like the tartarous acid, of entering into a number of combinations without ſuffering decompoſition: Theſe combinations form triple ſalts, or neutral ſalts with double baſes, which ought to have proper names. The ſalt of ſorrel, which is potaſh having oxalic acid combined in exceſs, is named acidulous oxalat of potaſh, in our new nomenclature.

The acid procured from ſorrel has been known to chemiſts for more than a century, being mentioned by Mr Duclos in the Memoirs of the Academy for 1688, and was pretty accurately deſcribed by Boerhaave; but Mr Scheele firſt ſhewed that it contained potaſh, and demonſtrated its identity with the acid formed by the oxygenation of ſugar.

Sect. XXXII.—*Obſervations upon Acetous Acid, and its Combinations.*

This acid is compoſed of carbon and hydrogen united together, and brought to the ſtate of an acid by the addition of oxygen; it is conſequently formed of the ſame elements with the tartarous, oxalic, citric, and malic acids, and

others, but the elements exiſt in different proportions in each of theſe; and it would appear that the acetous acid is in a higher ſtate of oxygenation than theſe other acids. I have ſome reaſon to believe, that the acetous radical contains a ſmall portion of azot; and as this element is not contained in the radicals of any vegetable acid, except the tartarous, this circumſtance is one of the cauſes of difference. The acetous acid, or vinegar, is produced by expoſing wine to a gentle heat, with the addition of ſome ferment: This is uſually the ley, or mother, which has ſeparated from other vinegar during fermentation, or ſome ſimilar matter. The ſpirituous part of the wine, which conſiſts of carbon and hydrogen, is oxygenated, and converted into vinegar: This operation can only take place with free acceſs of air, and is always attended by a diminution of the air employed, in conſequence of the abſorption of oxygen; wherefore it ought always to be carried on in veſſels only half filled with the vinous liquor ſubmitted to the acetous fermentation.

The acid formed during this proceſs is very volatile; it is mixed with a large proportion of water, and with many foreign ſubſtances, and to obtain it pure it muſt be diſtilled, in ſtone or glaſs veſſels, by a gentle fire. The acid which paſſes over in diſtillation is ſomewhat changed by the proceſs, and is not exactly of the ſame nature

nature with what remains in the alembic, but ſeems leſs oxygenated: This circumſtance has not been formerly obſerved by chemiſts.

Diſtillation is not ſufficient for depriving this acid of all its unneceſſary water; and, for this purpoſe, the beſt way is by expoſing it to a degree of cold of from 19° to 23° of Fahrenheit; by this means the aqueous part becomes frozen, and leaves the acid in a liquid ſtate, and conſiderably concentrated. In the uſual temperature of the air, this acid can only exiſt in the gaſeous form, and can only be retained by combination with a large proportion of water. There are other chemical proceſſes for obtaining the acetous acid, which conſiſt in oxygenating the tartarous, oxalic, or malic acids, by means of nitric acid; but there is reaſon to believe the proportions of the elements of the radical are changed during this proceſs. Mr Haſſenfratz is at preſent engaged in repeating the experiments by which theſe converſions are ſaid to be produced.

The combinations of acetous acid with the various ſalifiable baſes are very readily formed; but moſt of the reſulting neutral ſalts are not cryſtallizable, whereas thoſe produced by the tartarous and oxalic acids are, in general, hardly ſoluble. Tartarite and oxalat of lime are not ſoluble in any ſenſible degree: The maliats are a medium between the oxalats and acetites,

with respect to solubility, and the malic acid is in the middle degree of saturation between the oxalic and acetous acids. With this, as with all the acids, the metals require to be oxydated previous to solution.

The older chemists knew hardly any of the salts formed by the combinations of acetous acid with the salifiable bases, except the acetites of potash, soda, ammoniac, copper, and lead. Mr Cadet discovered the acetite of arsenic * ; Mr Wenzel, and the Dijon academicians, Mr de Lassone and Mr Proust, made us acquainted with the properties of the other acetites. From the property which acetite of potash possesses, of giving out ammoniac in distillation, there is some reason to suppose, that besides carbon and hydrogen, the acetous radical contains a small proportion of azot ; though it is not impossible but the above production of ammoniac may be occasioned by the decomposition of the potash.

TABLE

* Savans Etrangers, Vol. III.

TABLE *of the Combinations of Acetic Acid with the Salifiable Bafes, in the Order of Affinity.*

Bafes.	*Neutral Salts.*
Barytes	Acetat of barytes.
Potafh	potafh.
Soda	foda.
Lime	lime.
Magnefia	magnefia.
Ammoniac	ammoniac.
Oxyd of	
zinc	zinc.
manganefe	manganefe.
iron	iron.
lead	lead.
tin	tin.
cobalt	cobalt.
copper	copper.
nickel	nickel.
arfenic	arfenic.
bifmuth	bifmuth.
mercury	mercury.
antimony	antimony.
filver	filver.
gold	gold.
platina	platina.
Argil	argil.

Note.—All thefe falts were unknown to the older chemifts; and even thofe, who are moft verfant in modern difcoveries, are yet at a lofs whether the greater part of the falts produced by the oxygenated acetic radical belong properly to the clafs of acetites, or to that of acetats.—A.

SECT. XXXIII.—*Obſervations upon Acetic Acid, and its Combinations.*

We have given to radical vinegar the name of acetic acid, from ſuppoſing that it conſiſts of the ſame radical with that of the acetous acid, but more highly ſaturated with oxygen. According to this idea, acetic acid is the higheſt degree of oxygenation of which the hydro-carbonous radical is ſuſceptible; but although this circumſtance be extremely probable, it requires to be confirmed by farther and more deciſive experiments, before it be adopted as an abſolute chemical truth. We procure this acid as follows: Upon three parts acetite of potaſh or of copper, pour one part of concentrated ſulphuric acid, and, by diſtillation, a very highly concentrated vinegar is obtained, which we call acetic acid, formerly named radical vinegar. It is not hitherto rigorouſly proved that this acid is more highly oxygenated than the acetous acid, nor that the difference between them may not conſiſt in a different proportion between the elements of the radical or baſe.

TABLE

TABLE *of the Combinations of Succinic Acid with the Salifiable Bases, in the Order of Affinity.*

Bases.	*Neutral Salts.*
Barytes	Succinat of barytes.
Lime	lime.
Potash	potash.
Soda	soda.
Ammoniac	ammoniac.
Magnesia	magnesia.
Argil	argil.
Oxyd of	
zinc	zinc.
iron	iron.
manganese	manganese.
cobalt	cobalt.
nickel	nickel.
lead	lead.
tin	tin.
copper	copper.
bismuth	bismuth.
antimony	antimony.
arsenic	arsenic.
mercury	mercury.
silver	silver.
gold	gold.
platina	platina.

Note.—All the succinats were unknown to the older chemists.—A.

Sect. XXXIV. — *Obſervations upon Succinic Acid, and its Combinations.*

The ſuccinic acid is drawn from amber by ſublimation in a gentle heat, and riſes in a concrete form into the neck of the ſubliming veſſel. The operation muſt not be puſhed too far, or by too ſtrong a fire, otherwiſe the oil of the amber riſes along with the acid. The ſalt is dried upon blotting paper, and purified by repeated ſolution and cryſtallization.

The acid is ſoluble in twenty-four times its weight of cold water, and in a much ſmaller quantity of hot water. It poſſeſſes the qualities of an acid in a very ſmall degree, and only affects the blue vegetable colours very ſlightly. The affinities of this acid, with the ſalifiable baſes, are taken from Mr de Morveau, who is the firſt chemiſt that has endeavoured to aſcertain them.

Sect.

Sect. XXXV.—*Obſervations upon Benzoic Acid, and its Combinations with Salifiable Baſes* *.

This acid was known to the ancient chemiſts under the name of the Flowers of Benjamin, or of Benzoin, and was procured by ſublimation, from the gum or reſin called Benzoin: The means of procuring it, *viâ humidâ*, was diſcovered by Mr Geoffroy, and perfected by Mr Scheele. Upon benzoin, reduced to powder, pour ſtrong lime-water, having rather an exceſs of lime; keep the mixture continually ſtirring, and after half an hours digeſtion, pour off the liquor, and uſe freſh portions of lime-water in the ſame manner, ſo long as there is any appearance of neutralization. Join all the decanted liquors, and evaporate as far as poſſible, without occaſioning cryſtallization, and, when the liquor is cold, drop in muriatic acid till no more precipitate is formed. By the former part of the proceſs a benzoat of lime is formed, and, by the latter, the muriatic acid combines with the lime, forming muriat of lime, which remains diſſolved,

* Theſe combinations are called Benzoats of Lime, Potaſh, Zinc, &c.; but, as the order of affinity is unknown, the alphabetical table is omitted, as unneceſſary.—T.

diſſolved, while the benzoic acid, being inſoluble, precipitates in a concrete form.

Sect. XXXVI.—*Obſervations upon Camphoric Acid, and its Combinations with Salifiable Baſes* *.

Camphor is a concrete eſſential oil, obtained, by ſublimation, from a ſpecies of laurus which grows in China and Japan. By diſtilling nitric acid eight times from camphor, Mr Koſegarten converted it into an acid analogous to the oxalic; but, as it differs from that acid in ſome circumſtances, we have thought neceſſary to give it a particular name, till its nature be more completely aſcertained by farther experiment.

As camphor is a carbono-hydrous or hydro-carbonous radical, it is eaſily conceived, that, by oxygenation, it ſhould form oxalic, malic, and ſeveral other vegetable acids: This conjecture is rendered not improbable by the experiments of Mr Koſegarten; and the principal phenomena exhibited in the combinations of camphoric acid with the ſalifiable baſes, being very

* Theſe combinations, which were all unknown to the old chemiſts, are called Camphorats. The table is omitted as being only in alphabetical order.—T.

very ſimilar to thoſe of the oxalic and malic acids, lead me to believe that it conſiſts of a mixture of theſe two acids.

Sect. XXXVII.—*Obſervations upon Gallic Acid and its Combinations with Salifiable Baſes* *.

The Gallic acid †, formerly called the Principle of Aſtringency, is obtained from gall-nuts, either by infuſion or decoction with water, or by diſtillation with a very gentle heat. This acid has only been attended to within theſe few years. The committee of the Dijon Academy have followed it through all its combinations, and give the beſt account of it hitherto produced. Its acid properties are very weak; it reddens the tincture of turnſol, decompoſes ſulphurets, and unites to all the metals, when they have been previouſly diſſolved in ſome other acid.

* Theſe combinations, which are called Gallats, were all unknown to the older chemiſts; and the order of their affinity is not hitherto eſtabliſhed.—A.

† Till lately, the gallic acid was confounded with the *tanin*, or principle of aſtringency, with which it is contaminated or mixed. Theſe can be ſeparated, and poſſeſs very diſtinct properties. For an account of tanin, and the method of procuring pure gallic acid, ſee Part I. Chap. XI. § 1. 14.

acid. Iron, by this combination, is precipitated of a very deep blue or violet colour. The radical of this acid, if it deſerves the name of one, is hitherto entirely unknown; it is contained in oak, willow, marſh iris, the ſtrawberry, nymphæa, Peruvian bark, the flowers and bark of pomegranate, and in many other woods and barks.

Sect. XXXVIII.—*Obſervations upon Lactic Acid, and its Combinations with Salifiable Baſes* *.

The only accurate knowledge we have of this acid is from the works of Mr Scheele. It is contained in whey, united to a ſmall quantity of earth, and is obtained as follows: Reduce whey to one-eighth part of its bulk by evaporation, and filtrate, to ſeparate all its cheeſy matter; then add as much lime as is neceſſary to combine with the acid; the lime is afterwards diſengaged by the addition of oxalic acid, which combines with it into an inſoluble neutral ſalt. When the oxalat of lime has been ſeparated by decantation, evaporate the remaining liquor to the

* Theſe combinations are called Lactats; they were all unknown to the older chemiſts, and their affinities have not yet been aſcertained.—A.

the conſiſtence of honey; the lactic acid is diſ-ſolved by alcohol, which does not unite with the ſugar of milk and other foreign matters; theſe are ſeparated by filtration from the alco-hol and acid; and the alcohol being evapora-ted or diſtilled off, leaves the lactic acid be-hind.

This acid unites with all the ſalifiable baſes, forming ſalts which do not cryſtallize; and it ſeems conſiderably to reſemble the acetous acid.

TABLE

TABLE *of the Combinations of Saccho-lactic Acid with the Salifiable Bases, in the Order of Affinity.*

Bases.	*Neutral Salts.*
Lime	Saccholat of lime.
Barytes	barytes.
Magnesia	magnesia.
Potash	potash.
Soda	soda.
Ammoniac	ammoniac.
Argil	argil.
Oxyd of	
zinc	zinc.
manganese	manganese.
iron	iron.
lead	lead.
tin	tin.
cobalt	cobalt.
copper	copper.
nickel	nickel.
arsenic	arsenic.
bismuth	bismuth.
mercury	mercury.
antimony	antimony.
silver	silver.

SECT.

Note.—All these were unknown to the older chemists. —A.

Sect. XXXIX.—*Obſervations upon Saccho-lactic Acid, and its Combinations.*

A ſpecies of ſugar may be extracted, by evaporation, from whey; this ſubſtance has long been known in pharmacy, and has a conſiderable reſemblance to that procured from the ſugar-cane. This ſaccharine matter, like ordinary ſugar, may be oxygenated by means of nitric acid: For this purpoſe, ſeveral portions of nitric acid are diſtilled from it; the remaining liquid is evaporated, and ſet to cryſtallize, by which means cryſtals of oxalic acid are procured; at the ſame time, a very fine white powder precipitates, which is the ſaccho-lactic acid diſcovered by Scheele. It is ſuſceptible of combining with all the alkalies, with the earths, and even with the metals: Its action upon the latter is hitherto but little known, except that, with them, it forms difficultly ſoluble ſalts. The order of affinity in the table is taken from Bergman.

Table

TABLE *of the Combinations of Formic Acid, with the Salifiable Bafes, in the Order of Affinity.*

Bafes.	*Neutral Salts.*
Barytes	Formiat of barytes.
Potafh	potafh.
Soda	foda.
Lime	lime.
Magnefia	magnefia.
Ammoniac	ammoniac.
Oxyd of	
zinc	zinc.
manganefe	manganefe.
iron	iron.
lead	lead.
tin	tin.
cobalt	cobalt.
copper	copper.
nickel	nickel.
bifmuth	bifmuth.
filver	filver.
Argil	argil.

Note.—All unknown to the older chemifts.—A.

SECT. XL.—*Obſervations upon Formic Acid, and its Combinations.*

This acid was firſt obtained by diſtillation from ants, in the laſt century, by Samuel Fiſher. The ſubject was treated of by Margraff in 1749, and by Meſſrs Ardwiſſan and Ochrn of Leipſic in 1777. The formic acid is extracted from a large ſpecies of red ants, *formica rufa, Lin.* which form large ant hills in woody places. It is procured, either by diſtilling the ants with a gentle heat in a glaſs retort or an alembic; or, after having waſhed the ants in cold water, and dried them upon a cloth, by pouring on boiling water, which diſſolves the acid; or the acid may be procured by gentle expreſſion from the inſects, in which caſe it is ſtronger than in any of the former ways. To obtain it pure, we muſt rectify, by means of diſtillation, which ſeparates it from the uncombined oily and charry matter; and it may be concentrated by freezing, in the manner recommended for treating the acetous acid.

SECT. XLI.—*Obſervations upon Bombic Acid, and its Combinations with Acidifiable Baſes* *.

The juices of the ſilk-worm ſeem to aſſume an acid quality when that inſect changes from the larva to the chryſalis ſtate. At the moment of its eſcape from the latter to the butterfly form, it emitts a reddiſh liquor, which reddens blue paper, and which was firſt attentively obſerved by Mr Chauſſier of the Dijon Academy: He obtained the acid by infuſing ſilk worm chryſalids in alcohol, which diſſolves their acid without being charged with any of the gummy parts of the inſect; and, by evaporating the alcohol, the acid remains tolerably pure. The properties and affinities of this acid are not hitherto aſcertained with any preciſion; and we have reaſon to believe, that analogous acids may be procured from other inſects. The radical of this acid is probably, like that of the other acids from the animal kingdom, compoſed of carbon, hydrogen, and azot, with the addition, perhaps, of phoſphorus.

TABLE

* Theſe combinations, named Bombats, were unknown to the old chemiſts; and the affinities of the ſalifiable baſes with the bombic acid are hitherto undetermined.—A.

TABLE *of the Combinations of the Sebacic Acid with the Salifiable Baſes, in the Order of Affinity.*

Baſes.	*Neutral Salts.*
Barytes	Sebat of barytes.
Potaſh	potaſh.
Soda	ſoda.
Lime	lime.
Magneſia	magneſia.
Ammoniac	ammoniac.
Argil	argil.
Oxyd of	
zinc	zinc.
manganeſe	manganeſe.
iron	iron.
lead	lead.
tin	tin.
cobalt	cobalt.
copper	copper.
nickel	nickel.
arſenic	arſenic.
biſmuth	biſmuth.
mercury	mercury.
antimony	antimony.
ſilver	ſilver.

Note.—All theſe were unknown to the old chemiſts.—A.

SECT. XLII.—*Obſervations upon Sebacic Acid, and its Combinations.*

To obtain the ſebacic acid, let ſome ſuet be melted in a ſkillet over the fire, along with ſome quick-lime in fine powder, and conſtantly ſtirred, raiſing the fire towards the end of the operation, and taking care to avoid the vapours, which are very offenſive. By this proceſs the ſebacic acid unites with the lime into a ſebat of lime, which is difficultly ſoluble in water; it is, however, ſeparated from the fatty matters with which it is mixed by ſolution in a large quantity of boiling water. From this the neutral ſalt is ſeparated by evaporation; and, to render it pure, is calcined, re-diſſolved, and again cryſtallized. After this we pour on a proper quantity of ſulphuric acid, and the ſebacic acid paſſes over by diſtillation.

SECT. XLIII.—*Obſervations upon the Lithic Acid, and its Combinations with the Saliſiable Baſes* *.

From the later experiments of Bergman and Scheele, the urinary calculus appears to be a ſpecies of ſalt with an earthy baſis; it is ſlightly acidulous, and requires a large quantity of water for ſolution, three grains being ſcarcely ſoluble in a thouſand parts of boiling water, and the greater part again cryſtallizes when cold. To this concrete acid, which Mr De Morveau calls the Lithiaſic, we give the name of Lithic Acid, the nature and properties of which are hitherto very little known. There is ſome appearance that it is an acidulous neutral ſalt, or acid combined in exceſs with a ſaliſiable baſe; and I have reaſon to believe that it really is an acidulous phoſphat of lime; if ſo, it muſt be excluded from the claſs of peculiar acids.

* All the combinations of this acid, ſhould it finally turn out to be one, were unknown to the older chemiſts, and its affinities with the ſaliſiable baſes have not been hitherto determined.—A.

Table *of the Combinations of the Prussic Acid with the Salifiable Bases, in the Order of Affinity* *.

Bases.	*Neutral Salts.*
Potash	Prussiat of potash.
Soda	soda.
Ammoniac	ammoniac.
Lime	lime.
Barytes	barytes.
Magnesia	magnesia.
Oxyd of	
zinc	zinc.
iron	iron.
manganese	manganese.
cobalt	cobalt.
nickel	nickel.
lead	lead.
tin	tin.
copper	copper.
bismuth	bismuth.
antimony	antimony.
arsenic	arsenic.
silver	silver.
mercury	mercury.
gold	gold.
platina	platina.

Sect.

* All these were unknown to former chemists.—A.

Sect. XLIV.—*Observations upon the Pruſſic Acid, and its Combinations.*

As the experiments which have been made hitherto upon this acid ſeem ſtill to leave a conſiderable degree of uncertainty with regard to its nature, I ſhall not enlarge upon its properties, and the means of procuring it pure and diſengaged from combination. It combines with iron, to which it communicates a blue colour, and is equally ſuſceptible of entering into combination with moſt of the other metals, which are precipitated from it by the fixed alkalies, ammoniac, and lime, in conſequence of greater affinity The pruſſic radical, from the experiments of Scheele, and eſpecially from thoſe of Berthollet, ſeems compoſed of carbon and azot; hence it is an acid with a double baſe. The phoſphorus, which has been found combined with it, appears, from the experiments of Mr Haſſenfratz, to be only accidental.

Although this acid combines with alkalies, earths, and metals, in the ſame way with other acids, it poſſeſſes only ſome of the properties we have been in uſe to attribute to acids, and it may conſequently be improperly ranked here in the claſs of acids; but, as I have already obſerved, it is difficult to form a decided opinion

upon the nature of this fubftance, until the fubject has been farther elucidated by a greater number of experiments.

SECT. XLV.—*Obfervations on Chromic Acid, and its Combinations with the Salifiable Bafes.*

" Chromum * is a peculiar metal, which has lately been difcovered in the ftate of an acid, combined with lead, and with iron. It likewife is found in the ftate of an oxyd, in the emerald, which owes its colour to the prefence of this metal. The name which Vauquelin, its difcoverer, has chofen to diftinguifh it by, may be tranflated the Colouring Metal, from its remarkable property of communicating fplendid colours to all or moft of the compounds into which it enters, either in the acid, oxyd, or metallic ftates.

" The chromic acid is of a fine ruby red colour, and fhoots into prifmatic cryftals, which are foluble in water. It combines with all the alkalies, forming cryftallizable falts of a fine golden yellow colour; and unites with lead and iron; with the former, into beautiful ruby red cryftals. It is decompofible by means of the

* This Section is added to the prefent edition by the Tranflator.—T.

the blowpipe, along with phoſphoric acid, or borat of ſoda, into a green oxyd, which fuſes with either of theſe ſubſtances into emeraldine vitreous globules. It is decompoſed into a green oxyd by muriatic acid, which it oxygenates; and likewiſe by means of the blowpipe, in contact with charcoal; and is reducible to the metallic ſtate, by bedding it in charcoal-powder, and making it undergo a ſtrong heat.

" The order of its affinities are not yet aſcertained; but its combinations with ſalifiable baſes, may be denominated as follows:

Baſes.	*Neutral Salts.*
Potaſh	Chromat of potaſh.
Soda	——— ſoda.
Ammoniac	——— ammoniac.
Lead	——— lead *.
Iron, &c.	——— iron, &c.

" Only theſe mentioned above are hitherto known. The circumſtances, as yet publiſhed, reſpecting its ſtate of oxyd, and its reguline or metallic ſtate, are enumerated in Part I. Chap. XVI. Sect. VI."

SECT.

* " This ſubſtance has long been known, under the name of Red lead ore of Siberia. It is extremely beautiful; of a brilliant red colour, and in ſmall cryſtals on the ſurface of thin cakes, of what may be termed amorphous chromat of lead."—T.

Sect. XLVI.—*Obſervations on Zoonic Acid**.

" Berthollet, in analyzing animal ſubſtances by deſtructive diſtillation, has lately diſcovered a peculiar acid, to which he gives the name of *Zoonic.* In the fluid, which diſtils during the above proceſs, it is found combined with ammonia, from which it is detached by adding lime. From this combination, it is ſeparated by phoſphoric acid, which unites with the lime, and the zoonic acid comes over in diſtillation. This acid may likewiſe be obtained by a ſimilar proceſs, from the gluten of wheat, and the yeaſt of beer. It has a peculiar ſmell and ſtyptic taſte; reddens blue vegetable colours; cauſes effervеſcence with alkaline carbonats, and conſequently has greater affinity with the alkalies than the carbonic acid. Its combinations may be named as under:

Baſes.	*Neutral Salts.*
Potaſh	Zoonat of Potaſh.
Soda	——— Soda.
Ammonia, &c.	——— Ammonia, &c."

Sect.

* The whole of this Section is added by the Tranſlator to the preſent edition.—T.

Sect. XLVII.—*Obſervations on Suberic Acid* *.

" This acid is procured from cork, by means of diſtilling nitric acid from that ſubſtance, and probably might be obtained by a ſimilar proceſs from other vegetable matters. The reſiduum, after the diſtillation, and conſequent decompoſition of the nitric acid, is expoſed to moderate heat, until pungent ſuffocating vapours begin to ariſe. Twice its weight of water is then added to the reſiduum, and the heat continued; and, when cold, the ſolution of ſuberic acid is ſeparated from the inſoluble reſiduum by filtration. It may then be obtained ſolid, by evaporation; is volatile, or capable of being ſublimed, by heat; has a bitter acrid taſte; is ſoluble in water, and combines with the alkalies, earths, and ſome of the metals. Its order of affinities are not yet aſcertained; but its combinations, with the ſalifiable baſes, may be named *Suberats*."

Sect.

* This Section is added to the preſent edition by the Tranſlator.—T.

Sect. XLVIII.—*Recapitulation of the foregoing Obſervations on the Acids, and their Combinations* *.

"It was thought, that it might be conducive to the convenience and information of the reader, to ſubjoin the two following tables. The firſt, which is only a recapitulation of what is contained in the foregoing ſections, gives a general view of the order of affinities, of the ſalifiable baſes with the ſeveral acids, ſo far as is hitherto known. Such acids as have a ſimilar order of affinity with theſe baſes, are placed together, at the head of the ſame column, and thoſe of which the order of affinity, between them and the baſes, have not been hitherto aſcertained, are omitted.

"The ſecond table contains a ſpecimen of a general view of the new chemical nomenclature, as applied to the neutral ſalts, both in Latin and Engliſh. The firſt column contains the names of the ſeveral acids; the ſecond is a liſt of the Latin terms for the neutral ſalts which theſe produce by union with the ſalifiable baſes, as propoſed in the new French chemical nomenclature; the

* The whole of this ſection was added to the ſecond edition by the Tranſlator.—T.

the third is a fyftematic tranflation of thefe terms into Englifh, on exactly analogous principles: The fourth contains another fyftem of Latin nomenclature, founded on that of the French chemifts, but following rather the plan of Bergman, as already noticed in fome notes; the fifth and laft column is an analogous Englifh tranflation of thefe terms.

"In the former of thefe tables, the nomenclature recommended by Dr Black, as already mentioned in fome former notes, is adopted for the alkaline and earthy falifiable bafes; in the latter, the nomenclature ufed by the French chemifts for thefe fubftances, is retained in the fecond and third fections, but the propofed alteration is introduced in the fourth and fifth, together with a fimilar alteration, likewife formerly mentioned in fome notes, for giving names to the metallic oxyds, to diftinguifh thefe from the reguline or perfectly fimple ftate, analogous to alkalies. To tranflate this laft idea of nomenclature into Englifh, required fuch a violent change, that the ufual names of the metals in Englifh are retained; that, however, can induce no ambiguity, as it muft be generally underftood that no metal can enter into combination with an acid, unlefs it be previoufly oxydated."

TABLE

TABLE OF THE ACIDS IN THE ORDER OF AFFINITY.

I. Nitrous, Nitric, Sulphurous, Sulphuric, Muriatic, and Sebacic Acid.	II. Acetous, Acetic, and Formic Acids.	III. Boracic Acid.	IV. Nitro-muriatic Acid.
Baryta.	Baryta.	Calca.	Arga.
Lixa.	Lixa.	Baryta.	Ammona.
Trona.	Trona.	Magneſia.	Oxyds of
Calca.	Calca.	Lixa.	Antimony.
Magneſia.	Magneſia.	Trona.	Silver
Ammona.	Ammona.	Ammona.	Arſenic.
Arga.	Oxyds of	Oxyds of	Baryta.
Oxyds of	Zinc.	Zinc.	Oxyd of
Zinc.	Manganeſe.	Iron.	Biſmuth.
Iron.	Iron.	Lead.	Calca.
Manganeſe.	Lead.	Tin.	Oxyds of
Cobalt.	Tin.	Cobalt.	Cobalt.
Nickel.	Cobalt.	Copper.	Copper.
Lead.	Copper.	Nickel.	Tin.
Tin.	Nickel.	Mercury.	Iron.
Copper.	Arſenic.	Arga.	Magneſia.
Biſmuth.	Biſmuth.		Oxyds of
Antimony.	Mercury.		Manganeſe.
Arſenic.	Antimony.		Mercury.
Mercury.	Silver.		Molybdena.
Silver.	Gold.		Nickel.
Gold.	Platina.		Gold.
Platina.	Arga.		Platina.
			Lead.
			Lixa.
			Trona.
			Oxyds of
			Tungſtein.
			Zinc.

V. hoſphorous, Phoſphoric, Tungſtic, Tartarous, Oxalic, and Saccho-lactic Acids.	VI. Carbonic Acid.	VII. Murioxic Acid.
Calca.	Baryta.	Baryta.
Baryta.	Calca.	Lixa.
Magneſia.	Lixa.	Trona.
Lixa.	Trona.	Calca.
Trona.	Magneſia.	Magneſia.
Ammona.	Ammona.	Arga.
Arga	Arga.	
Oxyds as in Col. I.	Oxyds as in Col. I.	Oxyds as in Col. I.

VIII. luoric and Arſeniac Acids	IX. Citric Acid.	X. Pyro-lignous Acid.
Calca.	Baryta.	Calca.
Baryta.	Calca.	Baryta.
Magneſia.	Magneſia.	Lixa.
Lixa.	Lixa.	Trona.
Trona.	Trona.	Magneſia.
Ammona.	Ammona.	Ammona.
Oxyds as in Col. II.	Oxyds as in Col II.	Oxyds as in Col. II.
Arga.	omitting Tin, Nickel,	Arga.
	and Biſmuth.	
	Arga.	

XI. yro-mucous Acid.	XII. Succinic Acid.	XIII. Pruſſic Acid.
Lixa.	Baryta.	Lixa.
Trona.	Calca.	Trona.
Baryta.	Lixa.	Ammona.
Calca.	Trona.	Calca.
Magneſia.	Ammona.	Baryta.
Ammona.	Magneſia.	Magneſia.
Arga.	Arga.	Oxyds as in Col. I.
Oxyds as in Col. II.	Oxyds as in Col. I.	placing Silver before
nittin Silver, Gold,		Mercury.
d Platina.		

TABLE OF THE NOMENCLATURE

Acids.	Lavoiſier.	
	Latin.	Engliſh.
Sulphurous.	Sulphis potaſſæ	Sulphite of potaſh
	——— ſodæ	——— of ſoda
	——— ammoniæ	——— of ammoniac
Sulphuric.	Sulphas calcis	Sulphat of lime
	——— magneſiæ	——— of magneſia
	——— barytæ	——— of barytes
	——— argillæ	——— of argil
Phoſphorous.	Phoſphis potaſſæ	Phoſphite of potaſh
Phoſphoric.	Phoſphas ſodæ	Phoſphat of ſoda
Nitrous.	Nitris ammoniæ	Nitrite of ammoniac
Nitric.	Nitras argenti	Nitrat of ſilver
Oxygenated Nitric.	——— auri oxygenata	Oxygenated nitrat of gold
Muriatic.	Murias mercurii	Muriat of mercury
Oxygenated Muriatic.	——— potaſſæ oxygenata	Oxygenated muriat of potaſh
Boracic.	Boras ſodæ	Borat of ſoda
Acetous.	Acetis ammoniæ	Acetite of ammoniac
Acetic, &c.	Acetas cupri, &c.	Acetat of copper, &c.

OF THE NEUTRAL SALTS.

Proposed Alteration.	
Latin.	English.
Lixa ſulphuroſa	Sulphurous lixa
Trona ſulphuroſa	——— trona
Ammona ſulphuroſa	——— ammona
Calca ſulphurica	Sulphuric calca
Magneſia ſulphurica	——— magneſia
Baryta ſulphurica	——— baryta
Arga ſulphurica	——— arga
Lixa phoſphoroſa	Phoſphorous lixa
Trona phoſphorica	Phoſphoric trona
Ammona nitroſa	Nitrous ammona
Argenta nitrica	Nitric ſilver
Aura nitroxica	Nitroxic gold
Mercuria muriatica	Muriatic Mercury
Lixa murioxica	Murioxic lixa
Trona boracica	Boracic trona
Ammona acetoſa	Acetous ammona
Cupra acetica, &c.	Acetic copper, &c.

END OF VOL. I.

